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**Interim Bioventing Pilot Test Results Report  
for Building 8200  
Fort Carson, Colorado**

**Prepared For**



**The US Army Environmental Center  
Aberdeen Proving Ground, Maryland**

**Fort Carson  
Colorado Springs, Colorado**

**and**



**Air Force Center for Environmental Excellence  
Brooks Air Force Base  
San Antonio, Texas**

**November 1996**



**PARSONS  
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*AQM01-03-0588*

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**INTERIM BIOVENTING PILOT TEST RESULTS REPORT FOR  
BUILDING 8200**

**FORT CARSON  
COLORADO SPRINGS, COLORADO**

**Prepared for:**

**US Army Environmental Center  
Aberdeen Proving Ground, Maryland**

**Fort Carson, Colorado**

**and**

**Air Force Center for Environmental Excellence  
Brooks AFB, Texas**

**November 1996**

**Prepared by:**

**Parsons Engineering Science, Inc.  
1700 Broadway, Suite 900  
Denver, CO 80290**



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# **INTERIM BIOVENTING PILOT TEST RESULTS REPORT FOR BUILDING 8200 FORT CARSON, COLORADO**

## **1.0 INTRODUCTION**

An initial bioventing pilot test was performed by Parsons Engineering Science, Inc. (Parsons ES) at Building 8200 at Fort Carson, Colorado during the period from July 15 through August 7, 1996. The proposed scope of work for this site was performed for Fort Carson, the US Army Environmental Center (USAEC), and the Air Force Center for Environmental Excellence (AFCEE) Technology Transfer Division (ERT) under AFCEE contract F41624-92-D-8036, Order 0017. The purpose of this report is to describe the results of the initial pilot test at Building 8200 and to make recommendations for extended testing and full-scale system installation to determine the long-term impact of bioventing on site contaminants. Descriptions of the history, geology, and contamination at Building 8200 are presented in the bioventing pilot test work plan (Parsons ES, 1996).

The sources of vadose zone soil contamination at this site were four former 20,000-gallon underground storage tanks (USTs) that were used to store gasoline and diesel fuel [Rust Environmental & Infrastructure (RUST), 1994]. The tanks were removed by Parker Excavating during November 1996 (Cloonan, 1996a). Full-scale bioventing system installation is expected to occur in early 1997.

## **2.0 PILOT TEST DESIGN AND CONSTRUCTION**

A total of four Geoprobe<sup>®</sup> boreholes were installed by Parsons ES at the site to better define the extent of contamination, and to determine appropriate vapor monitoring point (MP) screen depths. Vapor MPs MPA, MPB, MPC, and MPG were installed by Parsons ES in Geoprobe<sup>®</sup> boreholes on July 16, 17, 18, and 26, 1996. Installation of an air injection vent well (VW) (VW2) and three additional vapor MPs (MPD, MPE, and MPF) using auger drilling methods took place on July 22 through 24, 1996. Drilling services were provided by Ground Exploration Company, Inc. of Arvada, Colorado, and VW and MP installation and soil sampling was directed by Mr. David Teets, the Parsons ES site manager. Electrical services were provided by Herb Wilson Electric, and concrete repair was completed by AAA Concrete, both of Colorado Springs, Colorado.

In addition to VW2 and the seven MPs (MPA through MPG), a blower unit was installed at the Building 8200 site. Existing monitoring well FCMW89, installed by ICF Kaiser Engineers (ICF Kaiser, 1992), also was used as a VW (VW1), and wells FCMW88, 8200-MW1, -MW2, and -MW3 were used as MPs. Figure 2.1 is a site layout showing the locations of the two VWs, seven new MPs, blower unit, existing groundwater monitoring wells, and previous soil borings at the site. The hydrogeology of the site is depicted in the cross-section on Figure 2.2. Borehole logs for the MPs and VWs are included in Appendix A. The background MP for this site was existing groundwater monitoring well 8200-MW5, which is screened several feet above the

# LEGEND

- VW2 ▲ NEW VENT WELL
- MPA ● NEW VAPOR MONITORING POINT
- FCMW89/VW1 ● EXISTING MONITORING WELL/VENT WELL
- SB1/8200-MW1 ● EXISTING MONITORING WELL
- DIRECT PUSH SOIL/WATER SAMPLING LOCATION
- PREVIOUS SOIL BORING LOCATION
- ① AIR EMISSIONS SAMPLING LOCATION
- ESTIMATED FORMER UST LOCATION
- FENCE
- A—A' LOCATION OF HYDROGEOLOGIC PROFILE (FIGURE 2.2)

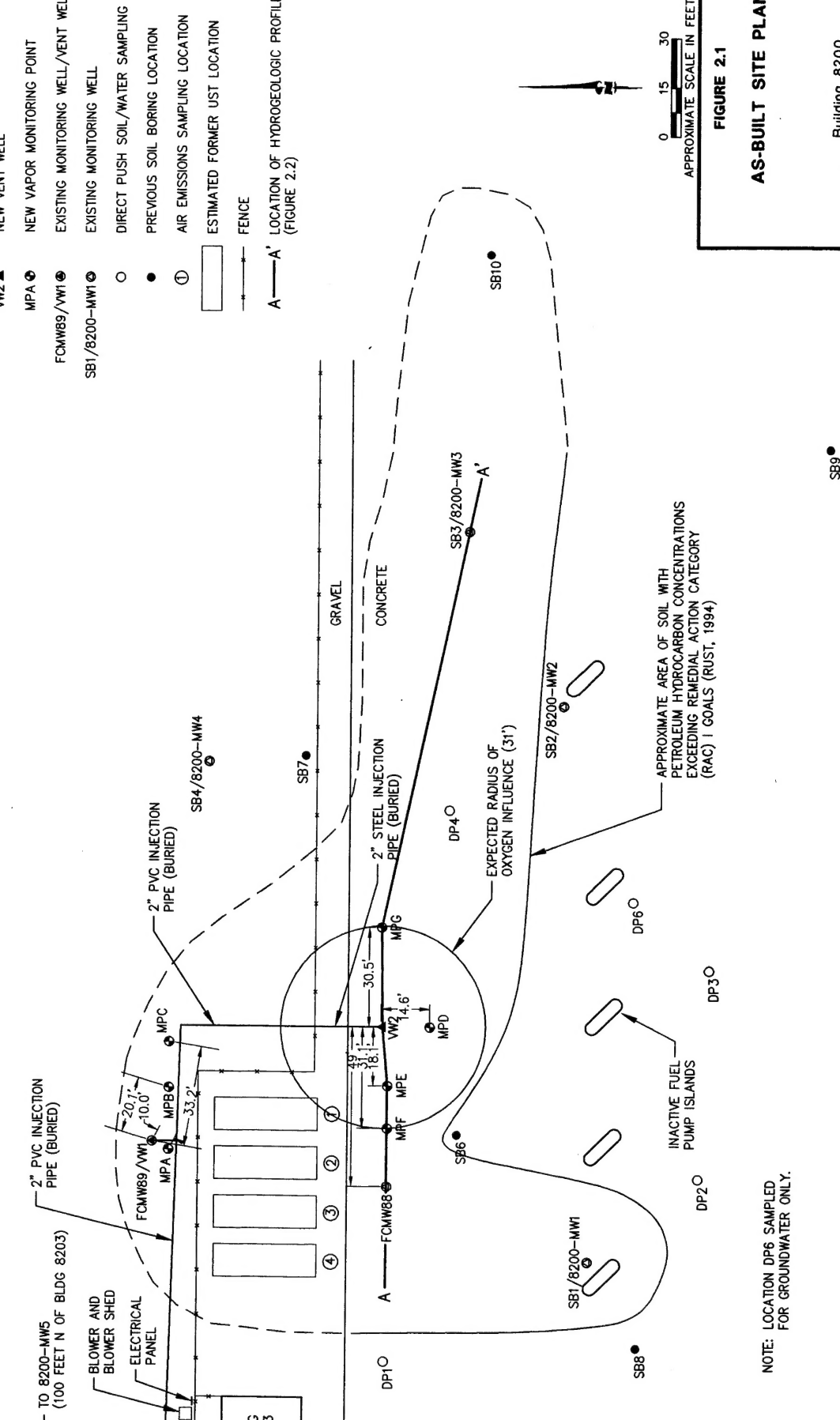


FIGURE 2.1

## AS-BUILT SITE PLAN

Building 8200  
Fort Carson, Colorado

**PARSONS  
ENGINEERING SCIENCE, INC.**  
Denver, Colorado

NOTE: LOCATION DP6 SAMPLED  
FOR GROUNDWATER ONLY.

SOURCE: RUST, 1994

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groundwater surface. Well 8200-MW5 is located approximately 100 feet north of Building 8203. The following sections describe the final design and installation of the bioventing system at Building 8200.

## 2.1 Air Injection Vent Well

The new air injection VW (VW2) was installed in highly contaminated soils approximately 25 feet southeast of the USTs, within the concrete-covered area (Figure 1.1). The VW was constructed using 4-inch-diameter, Schedule 40 polyvinyl chloride (PVC) casing and 0.02-inch slotted PVC screen. Table 2.1 summarizes the VW construction details. The total depth of the VW is 19.5 feet below ground surface (bgs), with the screened interval extending from 4.5 to 19.5 feet bgs. The annular space between the well casing and borehole was filled with 8-12 silica sand from the bottom of the borehole to approximately 6 inches above the top of the well screen. Granular bentonite was placed above the sand, and hydrated in place with potable water. The top of the well was completed with a 12-inch-diameter flush-mounted well box mounted in a rectangular concrete pad. Construction details for VW1 (Well FCMW89) and VW2 are presented on Figures 2.3 and 2.4, respectively.

## 2.2 Monitoring Points

The MP screens were installed at the depths listed on Table 2.1. The seven multidepth MPs (MPA, MPB, MPC, MPD, MPE, MPF, and MPG) at this site were constructed as shown in Figures 2.5 and 2.6. Monitoring points MPA, MPB, MPC, and MPG were installed in Geoprobe borings, and are constructed with a 6-inch-long, 0.375-inch outside-diameter (OD) stainless steel screen implant attached to 0.5-inch-OD, high-density polyethylene (HDPE) tubing that extends to the ground surface. The top of each 0.5-inch HDPE riser was completed with a 3/8-inch needle valve (Figure 2.5).

Monitoring points MPD, MPE, and MPF were installed in auger-drilled borings and were constructed using 6-inch sections of 1-inch-diameter PVC well screen with 0.25-inch-diameter PVC riser pipes extending to the ground surface. At the top of each riser, a ball valve and a 3/16-inch hose barb were installed. The top of each MP was completed with a flush-mounted metal well protector set in concrete. Thermocouples were installed at the 12- and 16-foot depths at MPF to measure the soil temperature profile at the site (Figure 2.6).

Soil gas samples could not be collected from several of the MP screened intervals (MPB-15.5, MPB-20, MPC-15, MPC-23, MPE-11, MPF-16, and MPG-22) due to perched groundwater or impermeable soil conditions. Future MP screens should be installed within a 3-foot sand pack interval to increase the MP surface area. The existing groundwater monitoring well 8200-MW5 was used as the background MP for this pilot test. 8200-MW5 is located in an uncontaminated area approximately 100 feet north of Building 8203 (Figure 2.1) and has a screened interval extending above the groundwater surface (Appendix A).

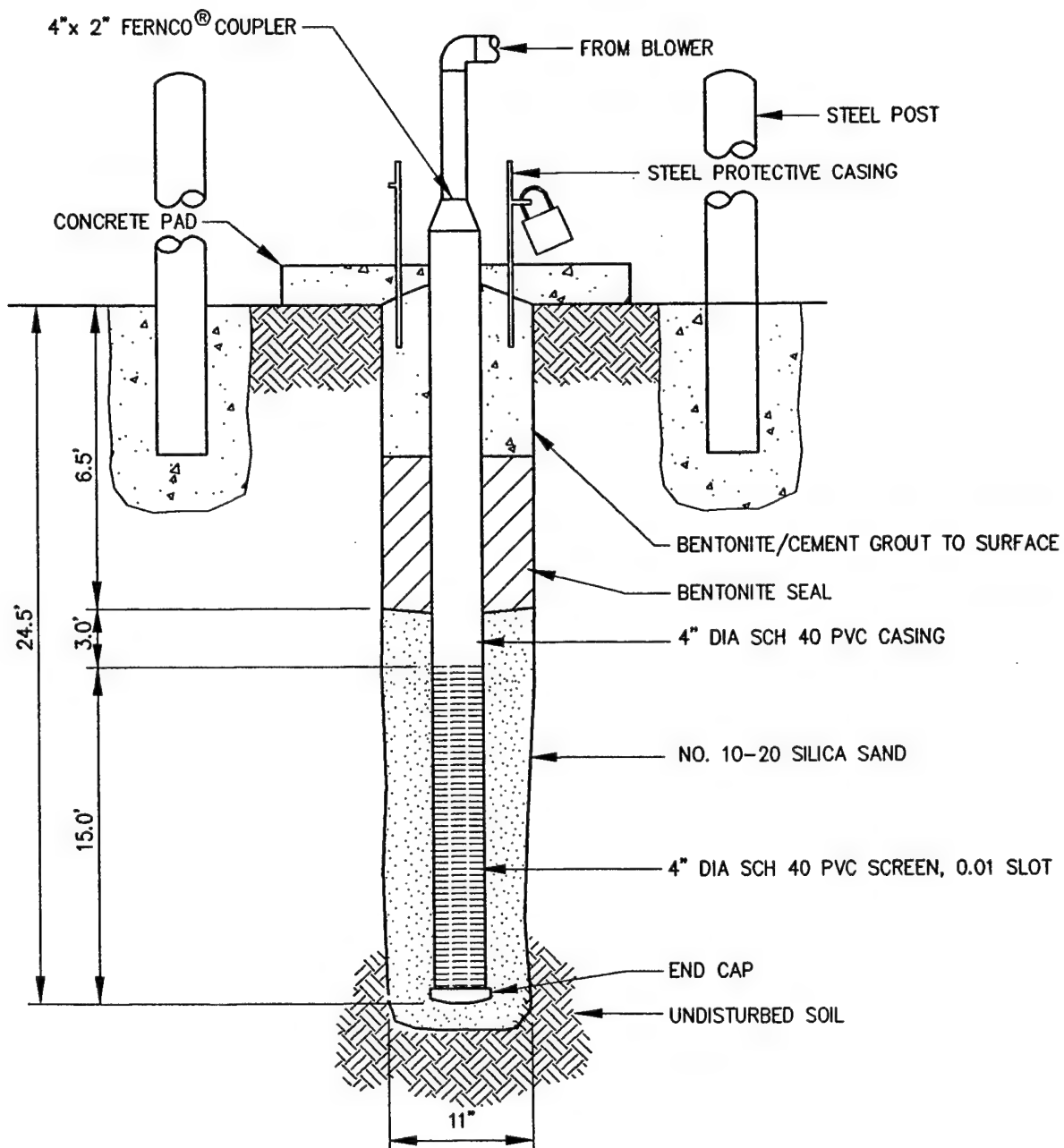
**TABLE 2.1**  
**VENT WELL AND MONITORING POINT CONSTRUCTION SUMMARY**  
**BUILDING 8200**  
**FORT CARSON, COLORADO**

<b>Location</b>	<b>Total Borehole Depth (feet bgs) <sup>a/</sup></b>	<b>Screened Interval (feet bgs)</b>	<b>Sand Pack Interval (feet bgs)</b>
FCMW88	30.0	14.5-29.5	10.5-30.0
FCMW89 (VW1)	25.0	9.5-24.5	6.5-25.0
8200-VW2	19.5	4.5-19.5	4.0-19.5
8200-MPA	22.0	16.0, 19.0	15.5-16.5, 18.5-19.5
8200-MPB	22.0	15.5, 20.0	15.0-16.0, 19.5-20.5
8200-MPC	24.0	15.0, 23.0	14.0-16.0, 22.0-24.0
8200-MPD	20.5	10.0, 18.0	8.0-12.0, 16.0-20.5
8200-MPE	20.0	7.0, 11.0	6.0-8.0, 10.0-12.5
8200-MPF	19.0	12.0, 16.0	11.0-13.0, 15.0-17.0
8200-MPG	24.0	13.0, 22.0	12.0-14.0, 19.0-24.0
8200-MW1	20.0	5.8-15.8	3.3-20.0
8200-MW2	18.5	7.6-17.6	6.0-18.5
8200-MW3	15.0	4.1-14.1	3.0-15.0
8200-MW4	17.3	6.8-16.8	3.0-17.3
8200-MW5 (BKGRD MP)	22.6	12.1-22.1	3.0-22.6

<sup>a/</sup> bgs = below ground surface.

Note: Monitoring points MPA, MPB, MPC, and MPG were installed in Geoprobe<sup>®</sup> borings.  
Vent well VW2 and monitoring points MPD, MPE, and MPF were installed in auger borings.  
Monitoring wells FCMW88 and FCMW89 installed by ICF Kaiser (1992).  
Monitoring wells 8200-MW1, -MW2, -MW3, -MW4, and -MW5 installed by RUST (1994).

# MONITORING WELL FCMW89



NOT TO SCALE

FIGURE 2.3

## MONITORING WELL FCMW89 (VW1) CONSTRUCTION DETAIL

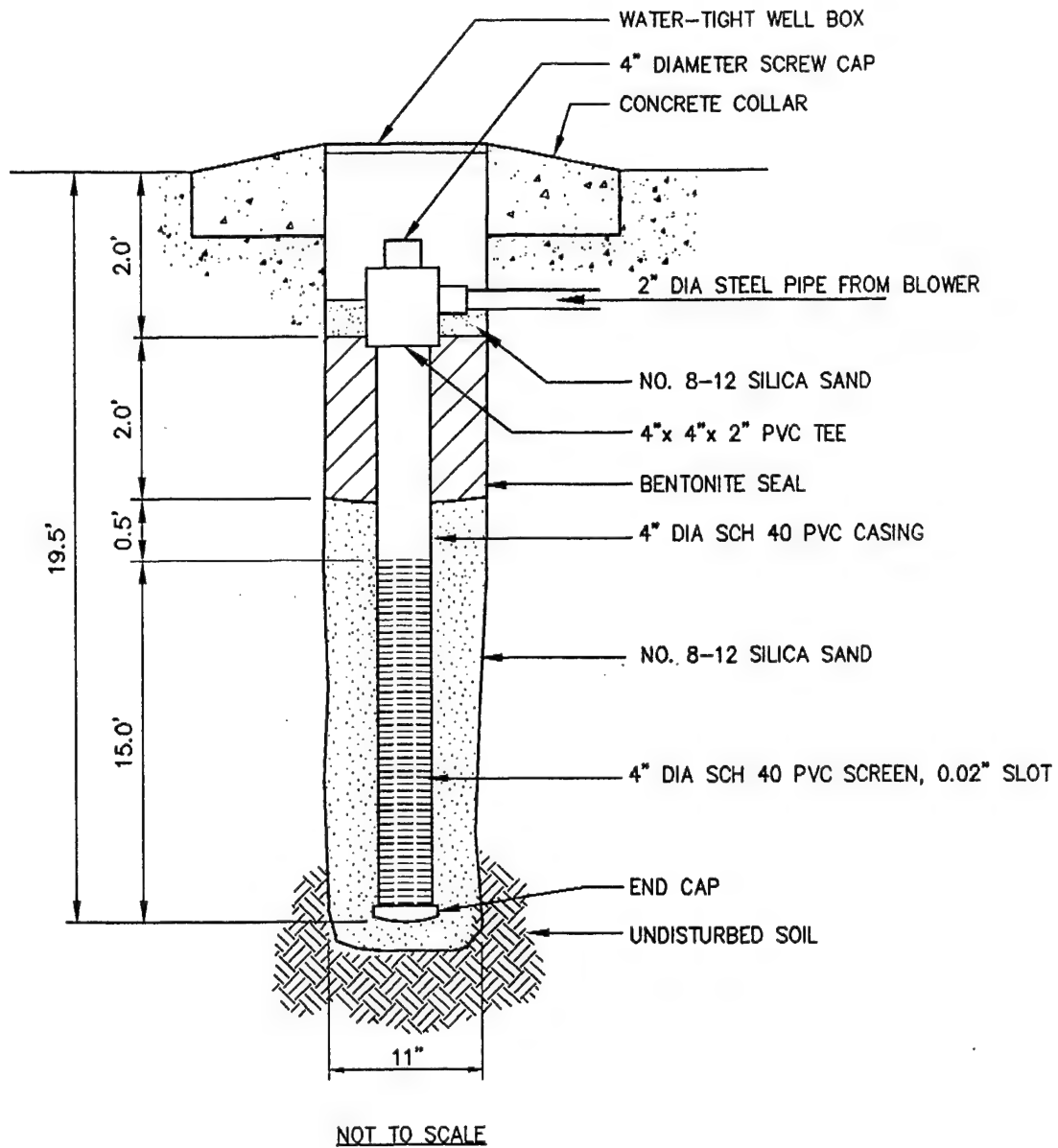
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Fort Carson, Colorado

**PARSONS  
ENGINEERING SCIENCE, INC.**

Denver, Colorado

Source: ICF Kaiser, 1992



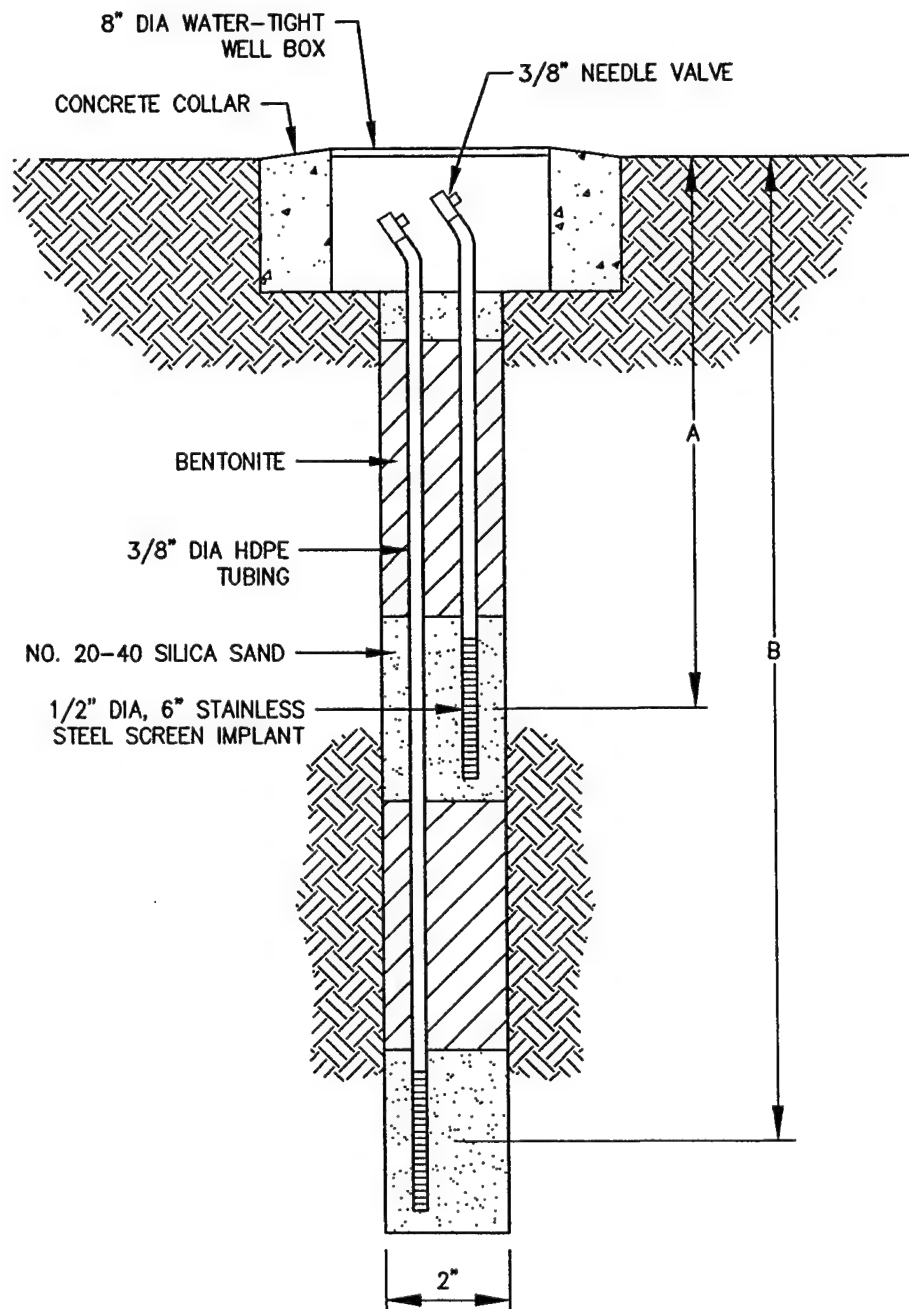


**FIGURE 2.4**  
**AS-BUILT**  
**INJECTION VENT WELL VW2**  
**CONSTRUCTION DETAIL**

Building 8200  
Fort Carson, Colorado

**PARSONS**  
**ENGINEERING SCIENCE, INC.**

Denver, Colorado



MONITORING POINT	DEPTH TO SCREENED INTERVALS (ft bgs) <sup>a/</sup>	
	A	B
MPA	16.0	19.0
MPB	15.5	20.0
MPC	15.0	23.0
MPG	13.0	22.0

<sup>a/</sup> ft bgs = FEET BELOW GROUND SURFACE

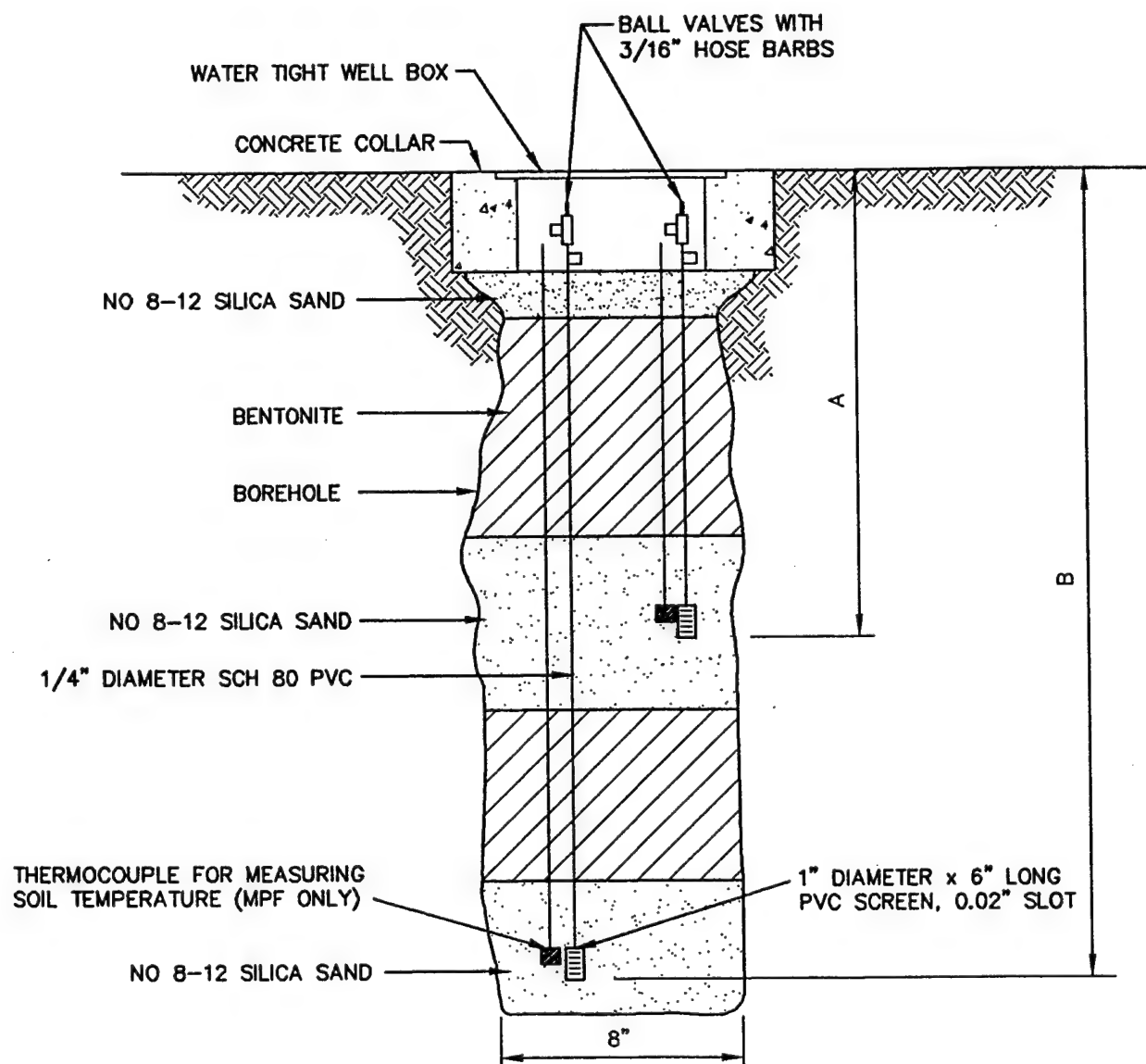
**FIGURE 2.5**

**AS-BUILT GEOPROBE<sup>®</sup>-INSTALLED  
MONITORING POINT  
CONSTRUCTION DETAIL  
(TYPICAL)**

Building 8200  
Fort Carson, Colorado

**PARSONS  
ENGINEERING SCIENCE, INC.**

Denver, Colorado



NOT TO SCALE

FIGURE 2.6

**AS-BUILT AUGER-INSTALLED  
MONITORING POINT  
CONSTRUCTION DETAIL  
(TYPICAL)**

Building 8200  
Fort Carson, Colorado

**PARSONS  
ENGINEERING SCIENCE, INC.**

Denver, Colorado

MONITORING POINT	DEPTH TO SCREENED INTERVALS (ft bgs) <sup>a/</sup>	
	A	B
MPD	10.0	18.0
MPE	7.0	11.0
MPF	12.0	16.0

<sup>a/</sup> ft bgs = FEET BELOW GROUND SURFACE

## 2.3 Blower Unit and Piping

A 2-horsepower Gast<sup>®</sup> regenerative blower unit was installed at Building 8200 for use in both the initial and extended pilot tests. The blower is energized by 230-volt, single-phase, 30-amp line power from a new distribution panel located on a new electrical panel installed adjacent to Building 8203 (Figure 2.1). The pilot test blower injected air into the subsurface at approximately 17.5 standard cubic feet per minute (scfm) for each of the three initial tests (at VW2, FCMW88, and FCMW89), and the injection flow rate was optimized at 13 scfm for each VW1 and VW2 for the extended pilot test. The final blower wiring was completed on July 18, 1996, and the system started on August 5, 1996. On November 22, 1996 it was discovered that the blower was not in operation. Upon restarting the blower, the blower pressure was set at 40 inches of water (Cloonan, 1996b). The blower configuration, instrumentation, and specifications for the initial pilot test and extended pilot test units are shown on Figure 2.7. Following the field mobilization, Parsons ES provided a bioventing system operations and maintenance (O&M) briefing checklist and blower maintenance manual to Ft. Carson personnel. A copy of the checklist is provided in Appendix B.

The air lines connecting the blower system to each VW consists of 2-inch diameter, Schedule 40 PVC within the gravel-covered area and 2-inch diameter galvanized steel pipe within the concrete area (Figure 2.1). The PVC pipe in the gravel-covered area was buried a minimum of 18 inches beneath the ground surface and bedded with native soil. Prior to excavating the pipe trenches, the existing concrete pavement was cut and removed. The steel pipe in the concrete-covered area was buried approximately 24 inches below the concrete surface and bedded in 3/8-inch pea gravel. After placing the steel pipe and backfill, the trench was patched with a minimum 12 inches of high-early-strength concrete. The concrete was reinforced with one parallel #4 reinforcing rod along the length of the trench, with cross ties spaced approximately every 2 feet. The concrete was tied into the existing concrete pavement using #4 dowels drilled into the existing concrete and tied to the #4 reinforcing bars running parallel to the trench.

The 2-horsepower blower system has sufficient reserve air-flow capacity to provide air to future, additional VWs. The blower has an air flow capacity of approximately 110 scfm at a pressure of 40 inches of water. The excess air flow is presently being bled off using a manual gate valve (Figure 2.7).

## 3.0 PILOT TEST RESULTS

### 3.1 Soil and Soil Gas Sampling Results

Soils at this site generally consist of approximately 30 feet of dense, brittle silt and clay soils overlying siltstone bedrock. In the vicinity of VW1, MPA, MPB, and MPC, groundwater is encountered at a depth of approximately 18 feet bgs. Groundwater was measured in VW2 at a depth of approximately 19.2 feet bgs following VW construction. Based on lithological observations made at VW2 and each MP, groundwater at the site appears to be perched in the more permeable soil intervals. At MPD, MPE, and MPF perched groundwater is present at a depth of approximately 16 to 17 feet bgs, and the saturated perched zone is approximately 1 foot thick. The groundwater surface becomes deeper in the direction of MPG. Saturated soil was

# LEGEND

- ① INLET AIR FILTER - SOLBERG F-30P-150
- ② VACUUM GAUGE (IN H<sub>2</sub>O)
- ③ BLOWER - CAST® 2.0HP R5125Q-50
- ④ MANUAL PRESSURE RELIEF (BLEED) VALVE 1 1/2" GATE
- ⑤ AUTOMATIC PRESSURE RELIEF VALVE
- ⑥ TEMPERATURE GAUGE - (°F)
- ⑦ PRESSURE GAUGE - (IN H<sub>2</sub>O)
- ⑧ FLOW CONTROL VALVE - 1 1/2" GATE
- ⑨ FLOW MEASURING PORT FITTED WITH PLUG
- ⑩ STARTER
- ⑪ BREAKER BOX - 220V/SINGLE PHASE/30 AMP

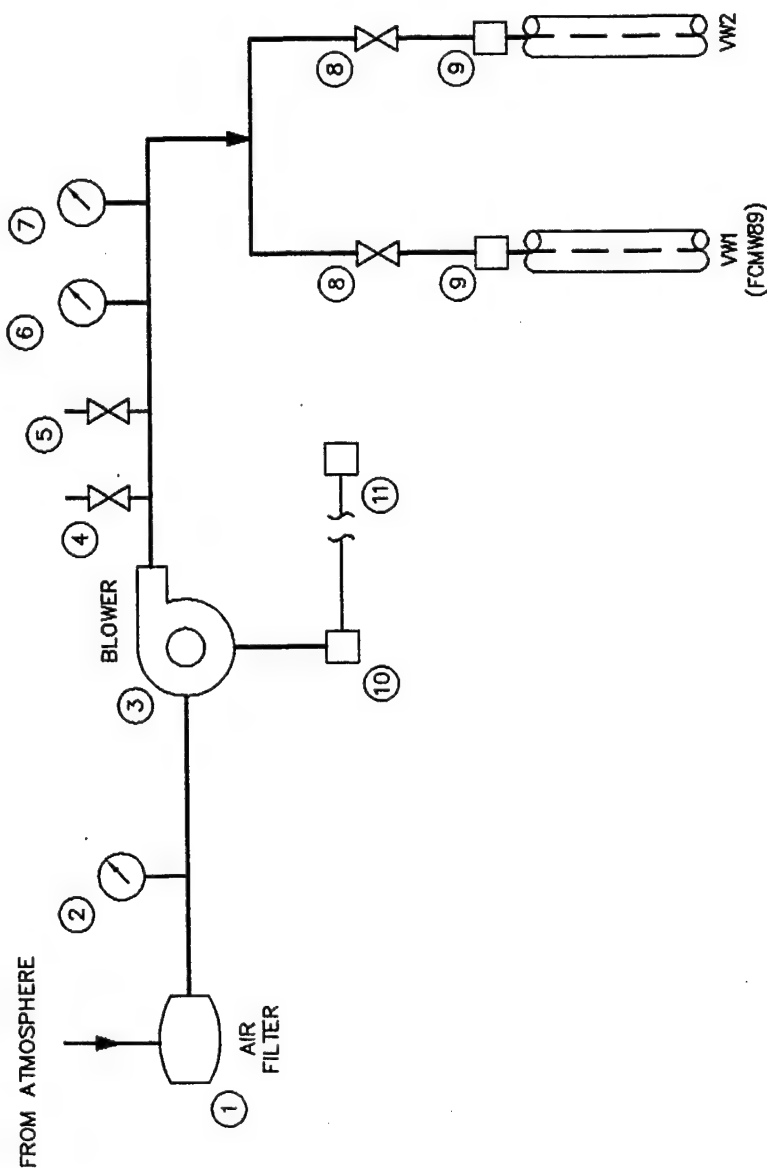
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**FIGURE 2.7**  
**AS-BUILT BLOWER SYSTEM**  
**INSTRUMENTATION**  
**DIAGRAM FOR AIR INJECTION**

Building 8200  
Fort Carson, Colorado

**PARSONS**  
**ENGINEERING SCIENCE, INC.**

Denver, Colorado



observed at a depth of approximately 19 feet bgs at MPG. More detailed geological information regarding Building 8200 can be found in the hydrogeologic cross-section (Figure 2.2) and the geologic boring logs (Appendix A).

Petroleum-hydrocarbon-contaminated soils at this site were encountered at depths corresponding to the perched groundwater at the VW2 and MP boreholes. Contaminated soils were identified based on odor, staining, and headspace volatile organic compound (VOC) field screening results. Contaminated soils were encountered in VW2 and all MP boreholes, with the highest contaminant concentrations occurring in the VW2 and MPE boreholes. Soils at these locations had a mild to strong hydrocarbon odor, and a petroleum-stained soil layer was encountered at depths between approximately 14 and 20 feet bgs in the two boreholes.

Soil samples for laboratory analysis were collected from Geoprobe<sup>®</sup> polybutyrate liners or split-spoon samplers. Soil sample headspace was screened for VOCs using a photoionization detector (PID) to determine the presence of contamination and to select soil samples for laboratory analysis. Soil samples for laboratory analysis were collected from depths of 16 to 21 feet bgs from the VW2, MPB, MPC, MPD, MPE, and MPF boreholes. A background soil sample was collected using the Geoprobe<sup>®</sup> rig from an apparently uncontaminated area adjacent to monitoring well 8200-MW5 at a depth of 11 feet bgs.

Soil samples were shipped via Federal Express<sup>®</sup> to Inchcape Testing Services, Inc. in Richardson, Texas for chemical and physical analysis. Soil samples were analyzed for total extractable petroleum hydrocarbons (TEPH) and total volatile petroleum hydrocarbons (TVPH) by US Environmental Protection Agency (EPA) Method 8015 (modified); and for benzene, toluene, ethylbenzene, and xylenes (BTEX) by EPA Method 8020. Three samples also were analyzed for iron, alkalinity, total Kjeldahl nitrogen (TKN), and several physical parameters. The background soil sample was analyzed for TKN only. Copies of the chain-of-custody forms are included in Appendix A. The results of these analyses are provided in Table 3.1.

Six soil gas samples for laboratory analyses were collected prior to performing the *in situ* respiration test in laboratory-provided, evacuated, 1-liter SUMMA<sup>®</sup> canisters. Soil gas samples were collected by extracting soil gas from monitoring wells FCMW89 (VW1) and 8200-MW3; VW2; at depths of 10 and 18 feet from MPD; and at a depth of 12 feet from MPF. All soil gas samples were collected following procedures outlined in the AFCEE bioventing protocol document (Hinchee *et al.*, 1992). Soil gas samples were shipped via Federal Express<sup>®</sup> to Air Toxics, Inc. in Folsom, California for total volatile hydrocarbon (TVH) and BTEX analysis by EPA Method TO-3. The results of these analyses are provided in Table 3.1.

### 3.2 Exceptions to Test Protocol Document Procedures and Work Plan

Procedures described in the protocol document (Hinchee *et al.*, 1992) generally were followed to complete the pilot test at Building 8200. Because the soil permeability varies across the site, three abbreviated permeability tests were performed at the site: one each at FCMW88, FCMW89 (VW1), and VW2. Initial soil gas sampling performed at existing monitoring wells prior to system installation indicated

**TABLE 3.1**  
**SOIL AND SOIL GAS ANALYTICAL RESULTS**  
**Building 8200**  
**Fort Carson, Colorado**

Analyte (Units) <sup>a/</sup>	Sample Location-Depth (feet below ground surface)						
	VW1-10-25	VW2-4-19	MPD-10	MPD-18	MPF-12	MW3-4-14	
Soil Gas Hydrocarbons	21,000	24,000	42	37,000	48,000	80	
TVH <sup>b/</sup> (ppmv)	85	94	0.026	48	56	0.059M <sup>c/</sup>	
Benzene (ppmv)	13	20	0.018	24	26	0.014M	
Toluene (ppmv)	7.8	4.3	0.013	3.7	7.8	0.014M	
Ethylbenzene (ppmv)	16	15	0.19	5.6M	5.0	0.20	
Xylenes (ppmv)							
Soil Hydrocarbons	VW2-16	MPB-21	MPC-21	MPD-19.5	MPF-17.5	MPF-17	
TVPH <sup>d/</sup> (mg/kg)	486	40.1	0.267	0.795	353	0.815	
TEPH <sup>e/</sup> (mg/kg)	865	272	<13.9 <sup>f/</sup>	<11.6	857	<11.7	
Benzene (µg/kg)	58	<31	4.2	1.3	380	<1.2	
Toluene (µg/kg)	114	<62	2.1J <sup>g/</sup>	<2.3	<580	<2.3	
Ethylbenzene (µg/kg)	365	46J	<2.8	<2.3	370J	<2.3	
Xylenes (µg/kg)	16,600	409	2.5J	1.8J	13,100	4.9	
Soil Inorganics	MPA-20	MPD-9	MPF-15	BG-11 <sup>h/</sup>			
pH (pH units)	8.0	7.6	7.6	-----			
Iron (mg/kg)	31,900	23,000	28,100	-----			
Alkalinity (mg/kg as CaCO <sub>3</sub> )	177	70.3	148	-----			
TKN (mg/kg)	314	1,200	711	460			
Phosphates (mg/kg)	55.3	51.3	46.3	-----			
Soil Physical Parameters	MPA-20	MPD-9	MPF-15	MPF-12	MPF-16		
Moisture (% wt.)	15.4	14.7	15.3	-----	-----		
Gravel (%)	0.0	0.0	0.0	-----	-----		
Sand (%)	2.3	11.1	13.3	-----	-----		
Silt (%)	67.7	55.8	54.5	-----	-----		
Clay (%)	30.0	33.2	32.3	-----	-----		
Temperature (°F)	-----	-----	-----	56.1	53.1		

<sup>a/</sup> mg/kg=milligrams per kilogram; ppmv=parts per million, volume per volume; TKN=total Kjeldahl nitrogen; TVH=total volatile hydrocarbons; TVPH=total volatile petroleum hydrocarbons; TEPH=total extractable petroleum hydrocarbons; CaCO<sub>3</sub> = calcium carbonate; wt.=weight; °F = degrees Fahrenheit.

<sup>b/</sup> TVH referenced as jet fuel (MW=156) and analyzed by USEPA Method TO-3.

<sup>c/</sup> M = Laboratory reported value may be biased due to apparent matrix interferences.

<sup>d/</sup> TVPH referenced as gasoline and analyzed for by USEPA Method SW8015 modified.

<sup>e/</sup> TEPH referenced as diesel and analyzed for by USEPA Method SW8015 modified.

<sup>f/</sup> < indicates that the analyte was not detected; the number provided is the method detection limit.

<sup>g/</sup> Benzene, toluene, ethylbenzene, and total xylenes analyzed by EPA Method SW8020.

<sup>h/</sup> J = Indicates a laboratory estimated value. This flag is used if the compound is detected but is below the reporting limit.

<sup>i/</sup> --- = Not analyzed.



that the soils north of the former tanks may be less permeable than the soils southeast of the tanks. Because no pressure response was observed during each of the tests, the test durations were shortened (4 to 8 hours is recommended). Further explanation of the permeability tests is provided in Section 3.4.

A total of seven MPs and one VW were installed at the site, rather than the five MPs and two VWs proposed in the work plan (Parsons ES, 1996). Difficulty in obtaining soil gas samples from MPB-15.5, MPB-20, MPC-15, MPC-23, MPE-11, MPF-16, and MPG-22 necessitated placement of additional MPs. MPD, MPE, and MPF were installed with an auger drill rig rather than the Geoprobe rig.

### 3.3 Initial Soil Gas Chemistry

Prior to initiating any air injection, soil gas in the two VWs, all MPs, and each of the existing onsite groundwater monitoring wells was analyzed for initial oxygen, carbon dioxide, and TVH concentrations using portable gas analyzers, as described in the technical protocol document (Hinchee *et al.*, 1992). Table 3.2 summarizes the initial soil gas chemistry. The VWs, MPs, and MWs were purged until oxygen levels had stabilized to remove stagnant gas prior to collecting soil gas samples.

At the VWs, FCMW88, 8200-MW1, 8200-MW2, 8200-MW3, and all MP screened intervals from which soil gas samples could be collected (except MPA), soil gas oxygen concentrations were below the atmospheric concentration of approximately 21 percent. Depleted oxygen concentrations indicate significant biological activity and soil contamination. The most significant oxygen depletion was measured at VW1, VW2, MPD-18, MPF-12, MPG-13, 8200-MW1, and 8200-MW2, where the oxygen concentrations were at or below 5 percent. Soil and soil gas results strongly indicate significant soil contamination at VW2. An oxygen concentration of 1.5 percent at this location corresponds with a total BTEX concentrations of 17,137 micrograms per kilogram ( $\mu\text{g/kg}$ ), in the soil sample from the 16 foot depth (Table 3.1). These results clearly indicate significant biological activity associated with contaminated soils. Initial oxygen concentrations at MPA-16, MPA-19, MPE-7, FCMW88, 8200-MW4, and 8200-MW5 ranged from 6.8 to 20.8 percent. These higher soil gas oxygen concentrations coupled with lower soil gas TVH concentrations (Table 3.2) indicate less fuel contamination (and resulting biological activity) at these locations.

TVH field measurements at the VWs and MPs ranged from 46 to greater than 20,000 parts per million, volume per volume (ppmv), and laboratory TVH results ranged from 42 to 48,000 ppmv. The highest TVH concentrations in MPs were measured at depths below 12 feet, indicating significant fuel contamination.

### 3.4 Air Permeability/Oxygen Influence

The depth and radius of oxygen increase in the subsurface resulting from air injection into the VW during pilot testing is the primary design parameter for expanded-scale bioventing system design. Optimization of expanded-scale and multiple VW systems require pilot testing to determine the volume of soil that can be oxygenated at a given flow rate and VW screen configuration.



**TABLE 3.2**  
**INITIAL SOIL GAS CHEMISTRY**  
**BUILDING 8200**  
**FORT CARSON, COLORADO**

Sample Location	Screen Depth (feet)	O <sub>2</sub> (%)	CO <sub>2</sub> (%)	Field TVH (ppmv) <sup>a/</sup>	Laboratory TVH (ppmv) <sup>b/</sup>
FCMW89(VW1)	9.5-24.5	3.0	7.4	6,200	21,000
8200-VW2	4.5-19.5	1.5	14.0	14,000	24,000
8200-MPA	16.0	20.8	0.05	0	--- <sup>c/</sup>
8200-MPA	19.0	20.8	0.05	2,000	---
8200-MPB <sup>d/</sup>	15.5	---	---	---	---
8200-MPB <sup>d/</sup>	20.0	---	---	---	---
8200-MPC <sup>d/</sup>	15.0	---	---	---	---
8200-MPC <sup>d/</sup>	23.0	---	---	---	---
8200-MPD	10.0	0.8	6.8	300	42
8200-MPD	18.0	0.9	5.3	>20,000	37,000
8200-MPE	7.0	6.8	5.2	46	---
8200-MPE	11.0	18.2	0.1	95	---
8200-MPF	12.0	0.0	6.6	20,000	48,000
8200-MPF <sup>e/</sup>	16.0	---	---	---	---
8200-MPG	13.0	5.0	5.8	78	---
8200-MPG <sup>d/</sup>	22.0	---	---	---	---
8200-MW1	5.8-15.8	4.1	3.8	2,200	---
8200-MW2	7.6-17.6	0.7	6.5	10,200	---
8200-MW3	4.1-14.1	0.0	9.1	200	80
8200-MW4	6.8-16.8	20.5	0.5	250	---
8200-MW5	12.1-22.1	19.8	1.4	260	---
FCMW88	14.5-29.5	8.4	4.0	65	---

<sup>a/</sup> Total volatile hydrocarbon field screening results reported in parts per million, volume per volume.

<sup>b/</sup> Laboratory total volatile hydrocarbon analytical results by EPA Method TO-3 referenced to jet fuel (molecular weight=156).

<sup>c/</sup> --- = Not analyzed.

<sup>d/</sup> Unable to obtain a soil gas sample due to impermeable soil conditions.

<sup>e/</sup> Monitoring point screened interval was within perched groundwater.

Abbreviated air permeability tests were conducted at each of wells FCMW88, FCMW89 (VW1), and VW2. A 1-hour permeability test was performed at well FCMW88 to determine the feasibility of utilizing the well for air injection during future expanded-scale system installation. Air was injected into FCMW88 for 1 hour at a rate of approximately 17.5 scfm and an average pressure of 50 inches of water. No pressure response was measured at MPF-12, MPE-7, and VW2. Following the first hour of air injection, the injection rate was increased to 18.5 scfm at a pressure of 62 inches of water. Again, no pressure response was measured at any of the monitoring locations. Following the permeability test at FCMW88, oxygen influence was measured at MPF-12, MPE-7, MPD-10, and MPD-18. Results indicated a 1 percent (%) increase in oxygen concentration at MPF-12 only. Based on the negligible pressure response observed from injecting at FCMW88, and the high blower pressure that was required, a new VW should be installed near FCMW88 during expanded-scale system installation.

Following oxygen influence measurements, air was injected into VW2 for 1.5 hours at a rate of approximately 19.5 scfm and an average pressure of 44 inches of water. No pressure response was measured at MPD-10, MPD-18, MPE-7, MPE-11, MPF-12, MPG-13, and FCMW88. After 1.5 hours of air injection, the air injection flow rate was increased to 22 scfm at a pressure of 58 inches of water. Again, no pressure response was observed at any of the MPs after an additional hour of air injection, therefore the permeability test was terminated. Following the permeability test at VW2 (after 2.5 hours of air injection), oxygen influence was measured at MPG-13, MPF-12, MPE-7, MPD-10, and MPD-18. Results indicated an oxygen concentration increase of 0.5% at MPG-13, 13.1% at MPF-12, 2.4% at MPE-7, 4.5% at MPD-10, and 0.0% at MPD-18.

Pressure response measurements were also collected following 46 hours of air injection at FCMW89 (VW1) and VW2. Again, no pressure response was observed at any of the MPs. At air injection flow rates of approximately 13.5 scfm at VW1 (FCMW89) and 15.3 scfm at VW2, and a blower pressure of 25 inches of water, no pressure response was observed at MPA (located 10 feet from VW1) or at any of the other MPs at the site. Due to the negligible pressure response at the site, an estimated soil gas permeability value could not be calculated. Pressure response measurements will be collected again prior to expanded-scale system installation activities.

Because the permeability tests did not provide information that was useful in determining the expected radius of oxygen influence, changes in soil gas oxygen levels were measured following a 46-hour injection period using the extended pilot test blower unit and VW-2. Results of this oxygen influence testing are presented in Table 3.3. This period of air injection produced increases in soil gas oxygen levels at all MPs (where a soil gas sample was obtainable) and monitored wells except 8200-MW1. Based on measured changes in oxygen levels, it is anticipated that the radius of influence for a long-term bioventing system at this site will exceed 31 feet at depths corresponding to the more permeable sand lenses. Within the less permeable fine grained soils, oxygen will likely diffuse from the permeable zones into the less permeable soils.

**TABLE 3.3**  
**INFLUENCE OF AIR INJECTION AT VW2 ON**  
**MONITORING POINT OXYGEN CONCENTRATIONS**  
**BUILDING 8200**  
**FORT CARSON, COLORADO**

Location	Distance From VW2 (feet)	Screen Depth (feet bgs) <sup>a/</sup>	Initial O <sub>2</sub> (%)	Final O <sub>2</sub> <sup>b/</sup> (%)	Initial TVH (ppmv) <sup>c/</sup>	Final TVH (ppmv) <sup>c/</sup>
MPD	14.6	10.0	13.5 <sup>d/</sup>	19.1	--- <sup>e/</sup>	---
MPD	14.6	18.0	9.1 <sup>d/</sup>	14.4	3,000	2,100
MPE	18.1	7.0	6.0 <sup>f/</sup>	8.9	0	0
MPF	31.1	12.0	0.0 <sup>f/</sup>	0.3	20,000	>20,000
MPG	30.5	13.0	17.5 <sup>d/</sup>	17.7	34	33
8200-MW1	96.0	5.8-15.8	4.1 <sup>g/</sup>	1.2	2,200	4,000
8200-MW2	114.7	7.6-17.6	0.7 <sup>g/</sup>	0.9	10,200	12,800
8200-MW3	149.0	4.1-14.1	0.3 <sup>g/</sup>	0.3	240	500

<sup>a/</sup> bgs = below ground surface.

<sup>b/</sup> Measurements taken after approximately 46 hours of air injection at VW2.

<sup>c/</sup> Field measurement for total volatile hydrocarbons (TVH) in parts per million, volume per volume.

<sup>d/</sup> Measurement taken following respiration testing and air injection at FCMW88, and prior to air injection at VW2.

<sup>e/</sup> --- = Not sampled.

<sup>f/</sup> Measurement taken following air injection at FCMW88 and prior to air injection at VW2.

<sup>g/</sup> Measurement taken prior to air injection at FCMW88 and VW2.

A radius of oxygen influence (RI) of at least 31 feet was observed at screened depths greater than 6 feet within the concrete-covered area. At 8200-MW2, located 115 feet from VW2 (Figure 2.1), the oxygen concentration increased from 0.7 to 0.9 percent following 46 hours of air injection. The observed oxygen increase may be attributable to inherent sampling inconsistencies; however, the TVH concentrations also increased, signifying that 8200-MW2 may actually be within the VW2 oxygen RI. In addition, soil gas monitored at 8200-MW1, which is located 96 feet from VW2, showed a decrease in oxygen concentrations, indicating that the soil gas was migrating outward from the area of higher contamination near VW2 into the area of lesser contamination near 8200-MW1. The expected RI at VW1 is likely less than that of VW2. Monitoring wells FCMW88 and FCMW89 (VW1) seem to have been constructed in a manner such that the permeability of the screened zone is less than that observed at the other site monitoring wells and at VW2. Because an oxygen-depleted MP at which soil gas was obtainable is not available near VW1, a MP should be installed near VW1 during expanded-scale system installation to determine the actual RI of VW1. Soil gas monitoring will be conducted prior to the expanded-scale system installation to better define the effective treatment radius.

### 3.5 *In Situ* Respiration Rates

The *in situ* respiration test was performed by injecting a mixture of air (oxygen) and approximately 10-percent helium (inert tracer gas) into VW2 and two MP screened intervals (MPD-10, and MPD-18) and injecting ambient air into MPG-13 for a 16-hour period. Oxygen loss and other changes in soil gas composition over time were then measured at these intervals. Oxygen, TVH, carbon dioxide, and helium were measured for a period of approximately 11 days following air injection. The measured oxygen losses were then used to calculate biological oxygen utilization rates. The results of *in situ* respiration testing for VW2, MPD-10, MPD-18, and MPG-13 are presented in Figures 3.1 through 3.4, respectively. Table 3.4 provides a summary of the oxygen utilization and fuel degradation rates.

Because helium is a conservative, inert gas, the change in helium concentrations over time can be useful in determining the effectiveness of the bentonite seals between MP screened intervals. Figures 3.1 through 3.3 compare oxygen utilization and helium retention. Because the observed helium losses were negligible, and because helium will diffuse approximately three times faster than oxygen due to oxygen's greater molecular weight, the measured oxygen loss can be inferred to be the result of bacterial respiration and not due to diffusion away from the MPs. Throughout the testing, helium concentrations increased, possibly due to varying helium injection flow rates.

Oxygen loss measured at VW2, MPD-10, MPD-18, and MPG-13 occurred at slow rates, ranging from 0.01 percent per hour at MPG-13 to 0.06 percent per hour at VW2. At VW2, the oxygen dropped from 20.8 percent to 14.0 percent in 10 days (14,580 minutes).

Based on these oxygen utilization rates, an estimated 20 to 80 mg of fuel per kg of soil can be degraded each year at this site. This conservative estimate is based on an average air-filled porosity of approximately 0.045 liter per kg of soil, and a ratio of 3.5

FIGURE 3.1  
INITIAL RESPIRATION TEST RESULTS AT VW2  
BUILDING 8200  
FORT CARSON, COLORADO

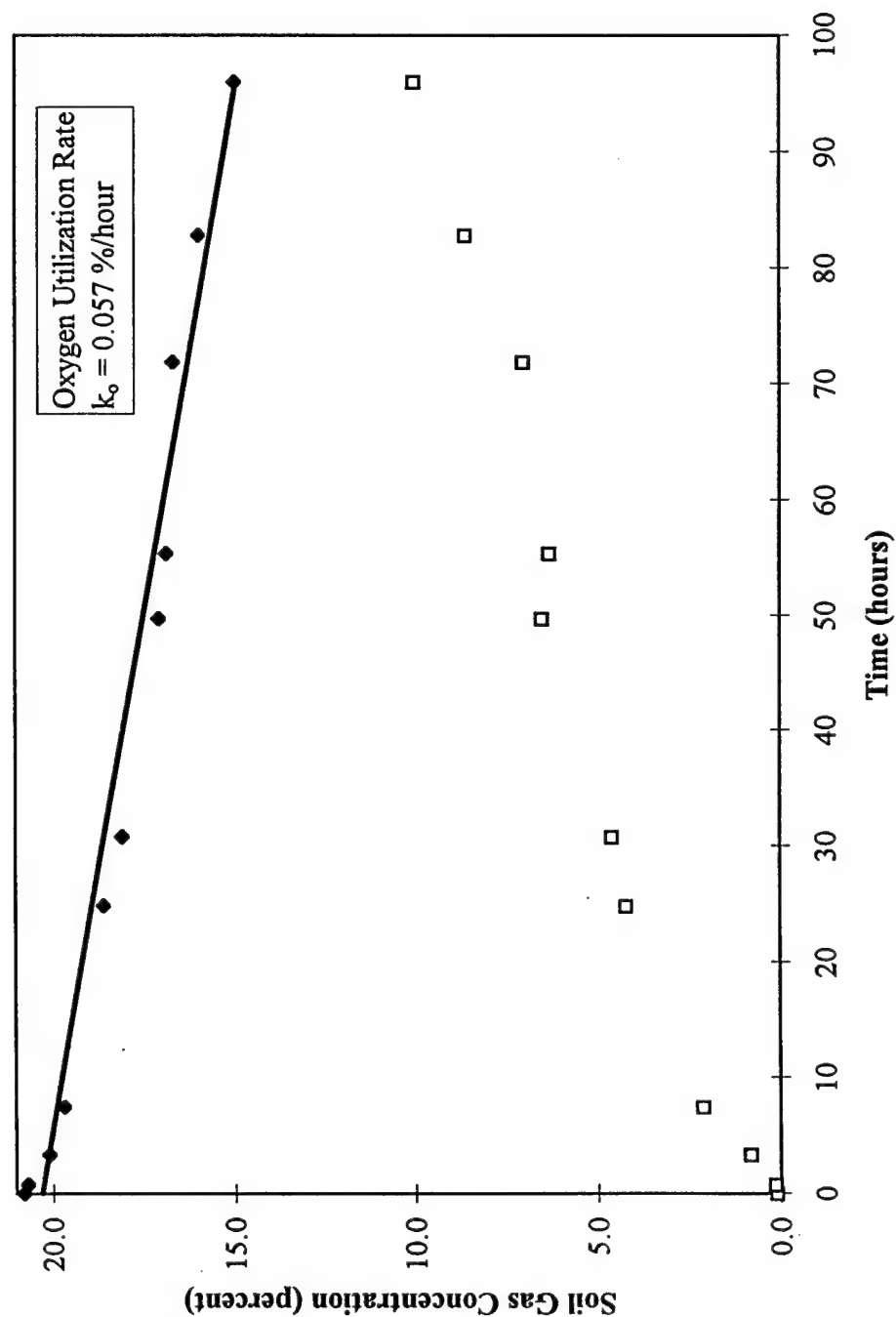


FIGURE 3.2  
INITIAL RESPIRATION TEST RESULTS AT MPD-10  
BUILDING 8200  
FORT CARSON, COLORADO

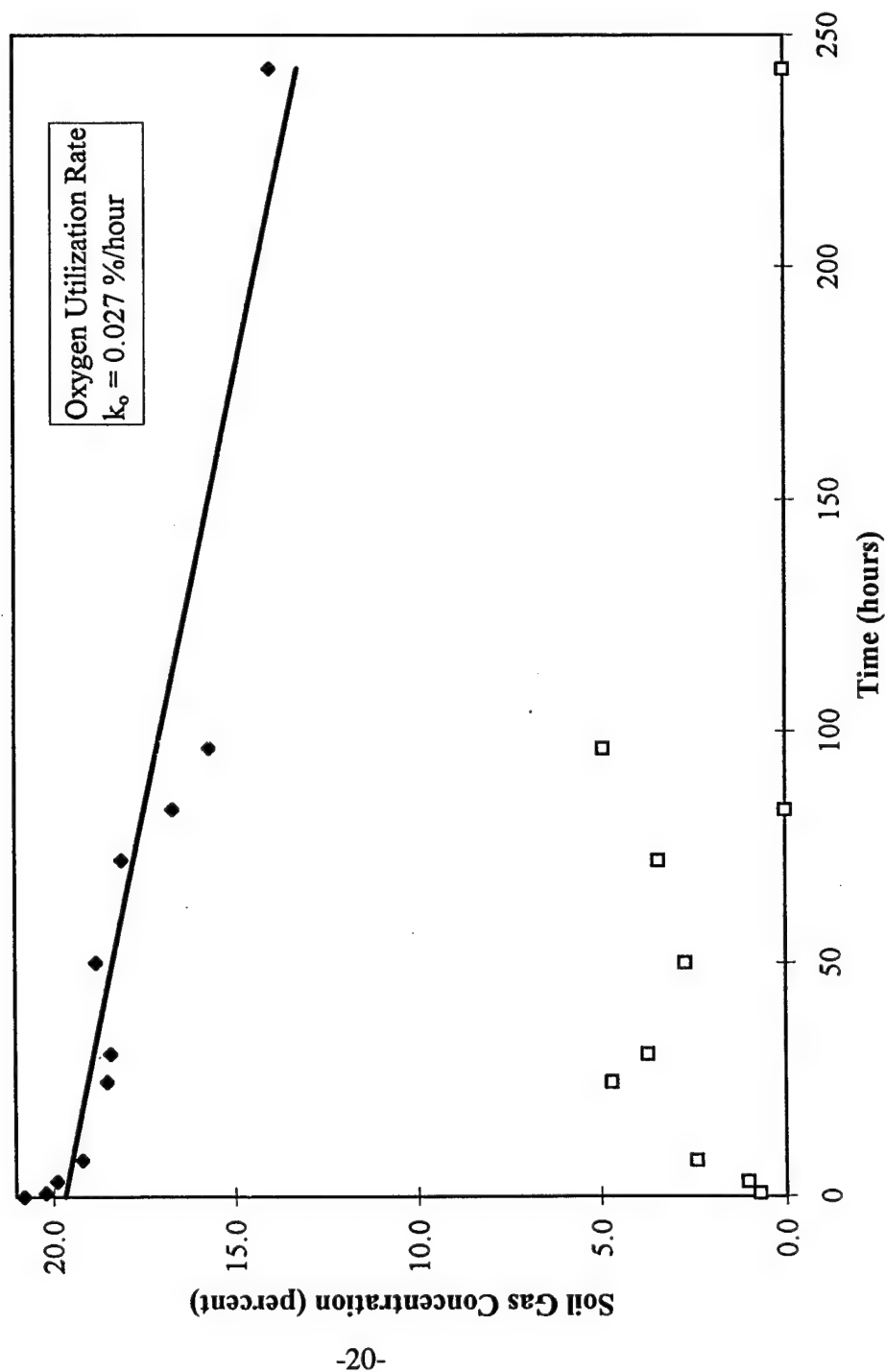


FIGURE 3.3  
INITIAL RESPIRATION TEST RESULTS AT MPD-18  
BUILDING 8200  
FORT CARSON, COLORADO

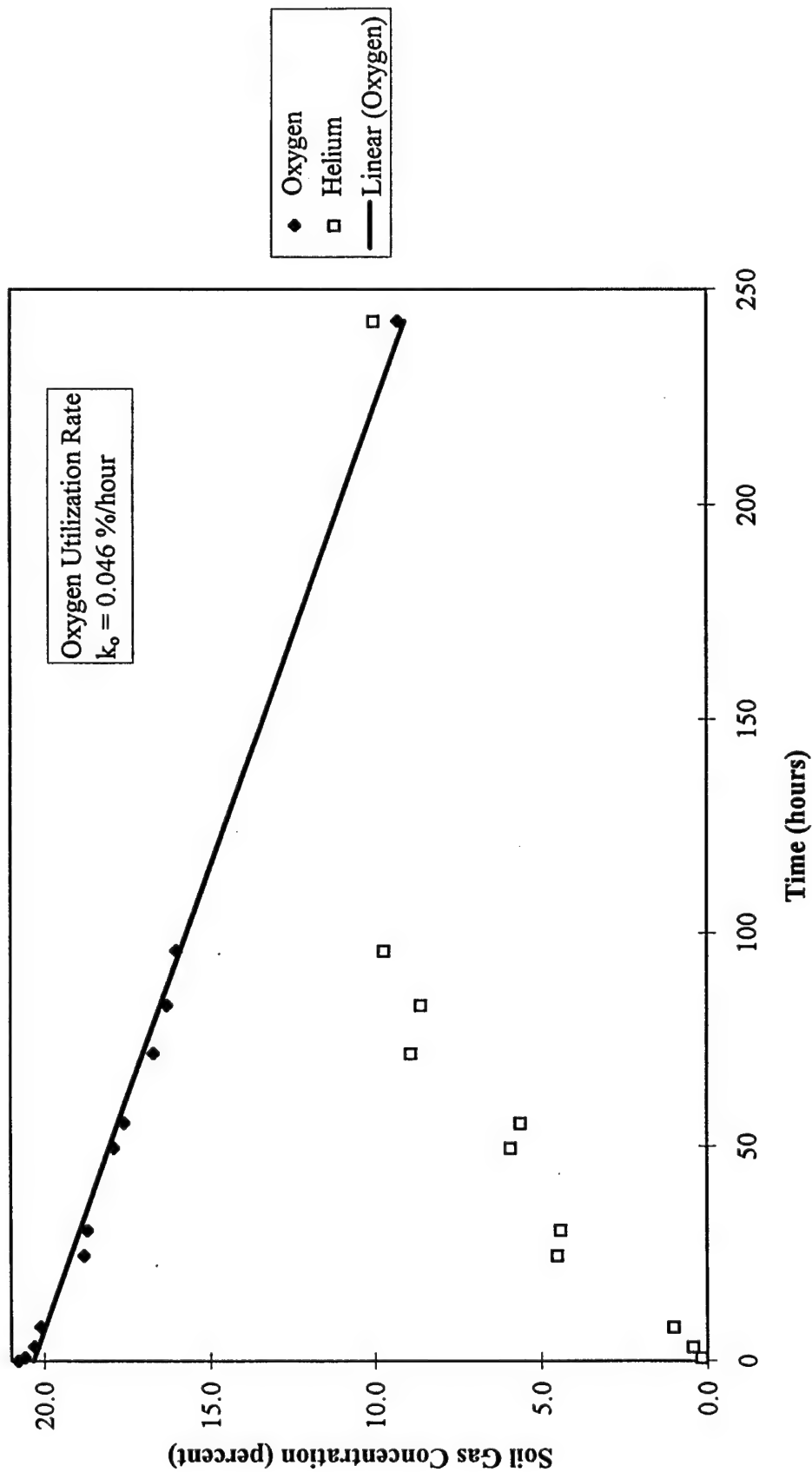
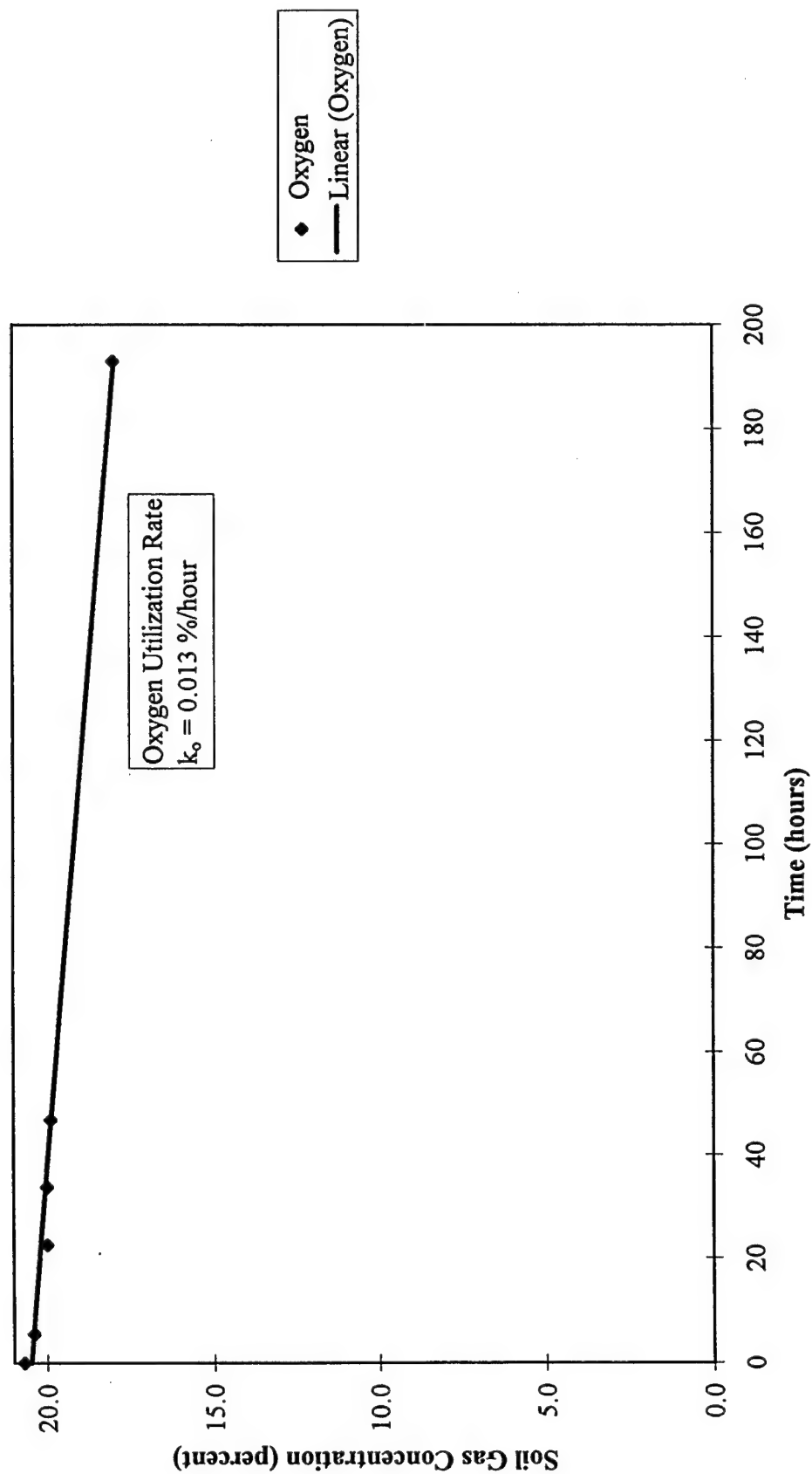


FIGURE 3.4  
INITIAL RESPIRATION TEST RESULTS AT MPG-13  
BUILDING 8200  
FORT CARSON, COLORADO





**TABLE 3.4**  
**OXYGEN UTILIZATION AND FUEL DEGRADATION RATES**  
**BUILDING 8200**  
**FORT CARSON, COLORADO**

Location- Depth (feet bgs) <sup>a/</sup>	Test Duration (hours)	O <sub>2</sub> Loss (%)	O <sub>2</sub> Utilization Rate <sup>b/</sup> (%/hour)	Fuel Degradation Rate (mg TPH/kg/year) <sup>c/</sup>
VW2 4.5-19.5	96	5.8	0.056	84
MPD-10	243	6.8	0.027	40
MPD-18	243	11.5	0.046	70
MPG-13	193	2.7	0.013	20

<sup>a/</sup> bgs = below ground surface.

<sup>b/</sup> Values based on best-fit lines (Figures 3.1 through 3.4).

<sup>c/</sup> mg TPH/kg/year = milligrams of total petroleum hydrocarbons degraded per kilogram of soil per year.

mg of oxygen consumed for every 1 mg of fuel biodegraded. Actual degradation rates may vary from these estimates.

### 3.6 Potential Air Emissions

The long-term potential for VOC air emissions from expanded-scale bioventing operations at this site is considered low because of the age and type of the site contaminants (greater than 5 years, and primarily diesel fuel); the very low air injection flow rates (13 scfm); and the concrete cover. Air emissions should be minimal because accumulated vapors will move slowly outward from the air injection points and will be biodegraded as they move horizontally through the soil.

Air emissions monitoring was conducted during pilot-scale system startup at four locations (Figure 2.1) using a GasTech total volatile hydrocarbon analyzer sensitive to 1 ppmv volatile hydrocarbons. Table 3.5 presents the results of both the initial and 2-hour readings. Because the potential for air emissions is highest during the initial hours of injection, and because no TVH emissions were detected, the long-term emission potential is considered low.

## 4.0 RECOMMENDATIONS

Initial bioventing tests at this site indicate that oxygen has been depleted in the contaminated soils, and that air injection is an effective method of increasing aerobic fuel biodegradation. A small, 2-horsepower regenerative blower has been installed at the site to continue air injection at a rate of approximately 13 scfm at each of the two VWs. It is recommended that air injection continue at this site to determine the long-term radius of oxygen influence and the effect of time, available nutrients, and changing temperatures on fuel biodegradation rates. Although biodegradation rates are slow at the Building 8200 site, Parsons ES recommends that expanded-scale bioventing be retained as the presumptive remedy for remediation of the vadose zone soils. As contracted under an Option 4 on the AFCEE Extended Bioventing Project, Parsons ES will prepare a Remedial Action Plan for Vadose Zone Soils and expanded-scale bioventing design package that will be delivered in early 1997. It is anticipated that expanded-scale system installation activities may begin as early as February 1997.

After one year of expanded-scale system operation, Parsons ES will collect soil gas samples from several monitoring points that were sampled during the initial sampling event and during the future expanded-scale system installation to determine the levels of cleanup achieved after approximately 1 year of *in situ* treatment.

The pilot-scale bioventing system is treating only a portion of the full-area extent (FAE) of vadose zone contamination. Based on the results of previous site investigations, several more VWs will be required to treat the FAE of petroleum contamination. Figure 4.1 shows the recommended VW and MP locations for expanded-scale bioventing system installation in the areas of known contamination. Results of additional site characterization work to be performed by Foothills Engineering Consultants will better define the FAE of contamination. It is recommended that expanded-scale system installation activities be coordinated with the site characterization field work. Site characterization soil borings may be converted for

**TABLE 3.5**  
**AIR EMISSIONS MONITORING RESULTS**  
**BUILDING 8200**  
**FORT CARSON, COLORADO**

<b>Emission Monitoring Location</b>	<b>Initial TVH (ppmv)<sup>a/</sup></b>	<b>Final TVH (ppmv)<sup>b/</sup></b>
1	0	0
2	0	0
3	0	0
4	0	0

<sup>a/</sup> TVH = total volatile hydrocarbons; ppmv = parts per million, volume per volume.

<sup>b/</sup> Final TVH readings were collected 2 hours after blower start up.

VW2 ▲	VENT WELL
MPA ●	VAPOR MONITORING POINT
9 / VW1 ●	MONITORING WELL / VENT WELL
3 - MW1 ●	MONITORING WELL
DP4 ○	PREVIOUS DIRECT PUSH SOIL / WATER SAMPLING LOCATION
SB-7 ●	PREVIOUS SOIL BORING LOCATION
⊕	RECOMMENDED SOIL BORING / VAPOR MONITORING POINT LOCATION
△	RECOMMENDED VENT WELL LOCATION
●	RECOMMENDED EXPLORATORY SOIL BORING / POTENTIAL VENT WELL LOCATION
—+—	FENCE



**CONCEPTUAL  
FULL-SCALE BIOVENTING  
SYSTEM DESIGN**

**PARSONS  
ENGINEERING SCIENCE, INC.**

SOURCE: RUST, 1994

use as VWs or MPs. VWs should be constructed in the same manner as VW2, and MPs should be constructed with the soil gas screens installed within 3-foot-thick sand pack intervals. Difficulty in obtaining soil gas samples from the recently installed MPs indicates that a thicker screened interval is necessary to ensure that each MP functions properly.

The current 2-horsepower blower system has sufficient capacity to provide air flow to about 5 additional VWs. Based on available site data, at least four additional VWs will be required at the Building 8200 site. Review of the construction details of the existing monitoring wells (Appendix A) indicates that 8200-MW3, which is located within the area of contamination is suitable for use as a VW. Also, monitoring wells 8200-MW1 and 8200-MW2 are suitable for use as vapor MPs. Therefore, it is recommended that at least four new VWs (including 8200-MW3) and five new MPs be installed at the site during expanded-scale system installation.

## 5.0 REFERENCES

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**APPENDIX A**  
**GEOLOGIC BORING LOGS,**  
**CHAIN-OF-CUSTODY FORMS,**  
**TEST DATA, AND CALCULATIONS**

**GEOLOGIC BORING LOG**

JOB NUMBER.: 726876.73330 CLIENT: AFCEE/AEC/Ft. Carson DATE: 7/23/86  
 BORING NUMBER: 8200-VW2 BORING DIA.: 11-inch ELEVATION: \_\_\_\_\_  
 RIG TYPE: CME 75 CONTRACTOR: Ground Exploration DATUM: \_\_\_\_\_  
 TEMPERATURE (°F): ~75°F WEATHER: Clear, breeze from NE GEOLOGIST: D. Teets  
 DRLG MED: HSA

COMMENTS:

Depth (ft.)	Pro- file	USCS	Geologic Description	Split Spoon Interval	Laboratory Sample Identification	Sample Type	PID ppmv	Remarks
1								Dark brown intervals
2								may = petroleum
3								staining
4								
5			4-5.5: Stiff Clay, silty, brittle, brn/ dark brn intervals, sm calcite present, iron oxide staining, dry, no odor or stain	X	1445	SS	es.5' 9.7/ 2.4	Recovery = 18/24 Blows: 6, 15, 20, 28
6			6-7.5: SAA	X	1455	SS	27.5' 10.0/ 2.4	Recovery = 18/24 Blows: 10, 18, 28, 39
7				X				
8			8-10: SAA except sl moist	X	1575	SS	29.5' 9.2/ 2.4	Recovery = 18/24 BH = 13.9/3.2 BZ = 3.2/3.2
9				X				
10			10-12: SAA except moist, more calcite content	X	1525	SS	210' 9.2/ 2.4	Blows: 14, 29, 43, 59 Recovery = 24/24 Blows: 12, 16, 20, 24
11				X				
12			12-14: SAA	X	1535	SS	212' 9.2/ 2.4	Recovery = 24/24 Blows: 7, 13, 19, 28
13				X				
14			14-16 SAA except fine odor starting at about 15'	X	1545	SS	214' 97.1/ 2.6	Recovery = 24/24 BH = 16.4/2.9 BZ = 2.9/2.9
15				X				
16			16-18 SAA except wet	X	1555	SS	215' 17.3/ 2.6	Blows: 9, 13, 21, 24 Recovery = 24/24
17			6w/o about 16' bgs	X	8200-VW2-16 TVH, TEH, BTEX		216' 354/ 2.6	Blows: 8, 11, 19, 26
18				X				
19			TD = 19.5' bgs				216.5' 528/ 4.5	220' BH = 122/2.6 BZ = 20.0/2.6
20								

PID - Photoionization Detector

BH - Borehole

SAA - Same As Above

Bkgrnd - Background

HSA - Hollow Stem Auger

ft - Feet

bgs - Below Ground Surface

na - Not Analyzed

ppmv - Parts per Million, Volume per Volume

HS - Sample Headspace

SS - Split Spoon Sample

BS - Brass Sleeve Sample

G - Grab Sample

## GEOLOGIC BORING LOG

JOB NUMBER.: 726876.73330 CLIENT: AFCEE/AEC/Ft. Carson DATE: 7/16/96  
 BORING NUMBER: 8200-MPA BORING DIA.: 2-inch ELEVATION: \_\_\_\_\_  
 RIG TYPE: Geoprobe CONTRACTOR: Parsons Engineering Science DATUM: \_\_\_\_\_  
 TEMPERATURE (°F): 75 WEATHER: Sunny GEOLOGIST: D. Teets  
 DRLG MED: Direct Push

COMMENTS:

Depth (ft.)	Pro-file	USCS	Geologic Description	Split Spoon Interval	Laboratory Sample Identification	Sample Type	PID ppmv	Remarks
1			14-16': Clay, sm silt, dark brn/lk brown w/ sm maroon, moist, no odor or staining	X				Sample / Bkgnd time 922
2			Recovery = 23"/24"	X		10		
3								
4								
5		6-8' GSA	4-6': Clay, tr f sand lenses, dk brn/lk brn w/white, dry, no odor or staining	X				749 Actually 6-8' GSA
6			Recovery = 22"/24"	X			CG 12.4 3.5	
7							CG 10.4 3.2	
8								
9								
10								
11			10-12': Clay, tr sand f lenses, dark brn/lk brn w/white, dry, no odor or staining	X			15.0 3.2	time 825
12			Recovery = 23"/24"	X			10	
13								
14							16.1 3.2	
15		12-14' GSA	12-14': Clay, sm sand f lenses, dark brn/lk brn w/white, dry to moist, no odor or staining	X			14.1 12.4 3.2	time 858
16			Full recovery	X			14 14 14	
17			16-18': Clay, sm silt, dark brown/lk brown w/white, moist, dense, no odor or staining	X			13.4 3.2 C16 14.8 2.7 18.5	time 1000
18			Recovery 24/24	X				
19								
20								

PID - Photoionization Detector

BH - Borehole

SAA - Same As Above

Bkgnd - Background

HSA - Hollow Stem Auger

ft - Feet

bgs - Below Ground Surface

na - Not Analyzed

ppmv - Parts per Million, Volume per Volume

HS - Sample Headspace

SS - Split Spoon Sample

BS - Brass Sleeve Sample

G - Grab Sample



**GEOLOGIC BORING LOG**

JOB NUMBER.: 726876.73330	CLIENT: AFCEE/AEC/Ft. Carson	DATE: 07/16/96
BORING NUMBER: 8200- MPA	BORING DIA.: 2-inch	ELEVATION:
RIG TYPE: Geoprobe	CONTRACTOR: Parsons ES	DATUM:
TEMPERATURE (°F): 75	WEATHER: Sunny	GEOLOGIST: D. Teets
	DRLG MED: direct push	

COMMENTS:

Depth (ft.)	Pro- file	USCS	Geologic Description	Split Spoon Interval	Laboratory Sample Identification	Sample Type	PID ppmv	Remarks
21			20-22': Clay, sm silt, drk brn/lt brn, dense v moist 20-21' odor, 21-22' odor and staining	X	8200-MPA-20 Physical parameters 8200-MPA-21 TVPH, TEPH, BTCL		107 2.4	Time 1055
22			recovery 24/24"				22'	
23								
24								
25								
26								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								

PID - Photoionization Detector

BH - Borehole

SAA - Same As Above

Bkgrnd - Background

HSA - Hollow Stem Auger

ft - Feet

bgs - Below Ground Surface

na - Not Analyzed

ppmv - Parts per Million, Volume per Volume

HS - Sample Headspace

SS - Split Spoon Sample

BS - Brass Sleeve Sample

G - Grab Sample

**GEOLOGIC BORING LOG**

JOB NUMBER.: 726876.73330 CLIENT: AFCEE/AEC/Ft. Carson DATE: 07/16/96  
 BORING NUMBER: 8200-MPB BORING DIA.: 2-inch ELEVATION:  
 RIG TYPE: Geoprobe CONTRACTOR: Parsons Engineering Science DATUM:  
 TEMPERATURE (°F): 80° WEATHER: GEOLOGIST: D. Teets  
 DRLG MED: Direct Push

COMMENTS:

Depth (ft.)	Pro- file	USCS	Geologic Description	Split Spoon Interval	Laboratory Sample Identification	Sample Type	PID ppmv	Remarks
1								sample/bkg
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15			14-16: Clay, tr sandiness, drk brn/lt brn moist, dense, no odor or staining				14 3.7 3.2	time 1500
16			recovery 23/24				16 15.4 3.2	time 1529
17			16-18: Clay, tr sand lenses, drk brn/lt brn, moist, dense, no odor or staining				18 16.3 3.2	time 1645
18			recovery 23/24"				22 379 2.9	
19			20-22: Clay, crystalline lenses, lt brn w/white crystals, moist, dense, odor and staining					
20			recovery 23/24"					

PID - Photoionization Detector

BH - Borehole

SAA - Same As Above

Bkgrnd - Background

HSA - Hollow Stem Auger

ft - Feet

bgs - Below Ground Surface

na - Not Analyzed

ppmv - Parts per Million, Volume per Volume

HS - Sample Headspace

SS - Split Spoon Sample

BS - Brass Sleeve Sample

G - Grab Sample

**GEOLOGIC BORING LOG**

JOB NUMBER.: 726876.73330 CLIENT: AFCEE/AEC/Ft. Carson DATE: 07/17/96  
 BORING NUMBER: 8200-MPC BORING DIA.: 2-inch ELEVATION: \_\_\_\_\_  
 RIG TYPE: Geoprobe CONTRACTOR: Parsons Engineering Science DATUM: \_\_\_\_\_  
 TEMPERATURE (°F): 75° WEATHER: Sunny GEOLOGIST: D. Teets  
 DRLG MED: Direct Push

COMMENTS: \_\_\_\_\_

Depth (ft.)	Pro- file	USCS	Geologic Description	Split Spoon Interval	Laboratory Sample Identification	Sample Type	PID ppmv	Remarks
1								sample/kg
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15			14-16': Clay, tr sand lenses, drk brn/lt brn, moist, dense, no odor or staining	X		014 13.8/ 2.9		time 852
16			recovery 24/24"	X		016 5.2/2.6		time 936
17			16-18': Clay, crystalline lenses, tr sand lenses, drk brn/lt brn w/white crystals, moist, no odor or staining	X		018 10.4/ 2.6		time 1027
18			recovery 24/24					sample caught in tube
19			18-20': Clay, sm silt, drk brn/lt brn, moist, no odor or staining					
20						020 15.4/2.6		

PID - Photoionization Detector

BH - Borehole

SAA - Same As Above

Bkgrnd - Background

HSA - Hollow Stem Auger

ft - Feet

bgs - Below Ground Surface

na - Not Analyzed

ppmv - Parts per Million, Volume per Volume

HS - Sample Headspace

SS - Split Spoon Sample

BS - Brass Sleeve Sample

G - Grab Sample

# GEOLOGIC BORING LOG

JOB NUMBER.: 726876.73330 CLIENT: AFCEE/AEC/Ft. Carson DATE: 07/17/96  
 BORING NUMBER: 8200- MPC BORING DIA.: 2 inch ELEVATION:  
 RIG TYPE: Geoprobe CONTRACTOR: Parsons ES DATUM:  
 TEMPERATURE (°F): 85 WEATHER: sunny GEOLOGIST: D. Teets  
 DRLG MED: Direct Push

COMMENTS:

Depth (ft.)	Pro-file	USCS	Geologic Description	Split Spoon Interval	Laboratory Sample Identification	Sample Type	PID ppmv	Remarks
21			20-22': Clay, sm silt, drk brn/tan w/t of copper, moist, dense, no odor or staining	X	8200-MPC-21 TVPI, TEPH, BTEX			time 1050
22			22-24': Clay, sm silt, drk brn/tan, moist, v dense, no odor or staining				22 60.2/ 2.6	time 1145 sample caught in tube
23								
24							24 84.4/ 2.6	time 1515 sample caught in tube
25			24-26': Clay, sm silt, drk brn, moist, v dense, no odor or staining					
26							26 2.5/ 2.5	
27								
28								
29			28-30': Clay, sm silt, sm sand, drk brn w/white silt, lb brn sand, moist, v dense, no odor or staining	X				time 1701 refusal @ 29' 30' gah
30							30 10.7/ 2.6	
31								
32								
33								
14								
15								
16								
17								
18								
19								
20								

PID - Photoionization Detector

BH - Borehole

SAA - Same As Above

Bkgrnd - Background

HSA - Hollow Stem Auger

ft - Feet

bgs - Below Ground Surface

na - Not Analyzed

ppmv - Parts per Million, Volume per Volume

HS - Sample Headspace

SS - Split Spoon Sample

BS - Brass Sleeve Sample

G - Grab Sample

**GEOLOGIC BORING LOG**

JOB NUMBER.: 726876.73330 CLIENT: AFCEE/AEC/Ft. Carson DATE: 07/18/96  
 BORING NUMBER: 8200- MPC 2 BORING DIA.: 2-inch ELEVATION: \_\_\_\_\_  
 RIG TYPE: Geoprobe CONTRACTOR: Parsons ES DATUM: \_\_\_\_\_  
 TEMPERATURE (°F): 80 WEATHER: cloudy GEOLOGIST: D. Teets  
 DRLG MED: Direct Push

COMMENTS: \_\_\_\_\_

Depth (ft.)	Pro- file	USCS	Geologic Description	Split Spoon Interval	Laboratory Sample Identification	Sample Type	PID ppmv	Remarks
21			20-22': Clay, lt silt, tr gypsum crystals, dk brn, moist, v dense, no odor or staining	X		20' 16.7/2.6 21-22' 14.4/2.6 22-23' 15.2/2.6 23-24' 14.1/2.6		sample/bkg time 922
22			recovery 24/24	X		22' 16.7/2.4 23' 28.3/2.0		time 1108
3			22-24': Clay, sm gypsum lenses, dk brn/lt brn, moist, v dense, odor and staining 22-23'	X		24' 10.8/3.2		
4			odors 23-24'					
5			recovery 24/24					
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								

PID - Photoionization Detector

BH - Borehole

SAA - Same As Above

Bkgnd - Background

HSA - Hollow Stem Auger

ft - Feet

bgs - Below Ground Surface

na - Not Analyzed

ppmv - Parts per Million, Volume per Volume

HS - Sample Headspace

SS - Split Spoon Sample

BS - Brass Sleeve Sample

G - Grab Sample

**GEOLOGIC BORING LOG**

JOB NUMBER.: 726876.73330 CLIENT: AFCEE/AEC/Ft. Carson DATE: 7/23/96  
 BORING NUMBER: 8200-MPD BORING DIA.: 2-inch 8-inch ELEVATION: \_\_\_\_\_  
 RIG TYPE: Geoprobe M575 CONTRACTOR: Parsons Engineering Science (Grand Ex) DATUM: \_\_\_\_\_  
 TEMPERATURE (°F): ~80°F WEATHER: \_\_\_\_\_ GEOLOGIST: D. Teets  
 DRLG MED: Direct Push - Solid Stem

COMMENTS:

Depth (ft.)	Pro-file	USCS	Geologic Description	Split Spoon Interval	Laboratory Sample Identification	Sample Type	PID ppmv	Remarks
1			0-1' Concrete					Dark brown intervals may = petroleum staining
2								
3								
4								
5			4-6' Clay, silty, dense brittle, calcite present, brown silty iron oxide staining, dry, no staining or odor. Shift (weathered shale bedrock)		0945	SS	e6' 11.5 10.2	Recovery = 23/24 Blows: 6, 12, 18, 22
6			6-8 SAA, except some dark brown intervals		0955		e8' 11.0 8.7	Recovery = 20/24 Blows: 32, 38, 53, 54
7								
8								
9			8-10 SAA except more calcite & dark brown intervals, very shift		1010 8200-MPD-9 for physical parameters		e10' 11.1 3.0	Recovery = 21/24 BH = 2.8/2.8 BSZ = 2.8/2.8 Blows: 16, 25, 37, 48
10								
11			10-12 SAA		1020		e12' 9.7 5.6	Recovery = 24/24 Blows: 41, 54, 58, 58
12								
13			12-14 Clay, silty, very shift brittle, more calcite present, brown/dark brown intervals, dry, No odor.		1030		e14' 9.4 2.5	Recovery = 24/24 Blows: 13, 16, 25, 28 PIDEIS = 10, 51, 5, 6
14								
15			14-16 SAA except more calcite present e15' 3" of moist clay		1040		e16' 10.2 5.6	Recovery = 24/24 Blows: 34, 40, 39, 44
16								
17			16-18 SAA		1055		e18' 12.9 5.5	Recovery = 24/24 BH = 7.6/7.4 BSZ = 7.4/7.4 Blows: 11, 18, 29, 38
18								
19			18-19.5 SAA, except more dense slight petroleum odor		1105		e19.5 15.0 6.0	Recovery = 18/24 Blows: 40, 58, 70, -
20			TD = 20.5				e20' BH = 50.0/5.0	

PID - Photoionization Detector

BH - Borehole

SAA - Same As Above

Bkgrnd - Background

HSA - Hollow Stem Auger

ft - Feet

bgs - Below Ground Surface

na - Not Analyzed

ppmv - Parts per Million, Volume per Volume

HS - Sample Headspace

SS - Split Spoon Sample

BS - Brass Sleeve Sample

G - Grab Sample

## GEOLOGIC BORING LOG

JOB NUMBER.: 726876.73330 CLIENT: AFCEE/AEC/Ft. Carson DATE: 7/24/96  
 BORING NUMBER: 8200-MPE BORING DIA.: 2 inch 11-inch ELEVATION:  
 RIG TYPE: Geoprobe CME75 CONTRACTOR: Parsons Engineering Science (Grand Ex.) DATUM:  
 TEMPERATURE (°F): ~75°F WEATHER: Clady, calm GEOLOGIST: D. Teets  
 DRLG MED: Direct Push HSA

## COMMENTS:

Depth (ft.)	Pro-file	USCS	Geologic Description	Split Spoon Interval	Laboratory Sample Identification	Sample Type	PID ppmv	Remarks
1								
2								
3								
4							85.5 2.4	
5							26.1 11.3 2.4	
6			5-6.4' Clay, silty, stiff, brittle, brn/blk intervals, calcite present, iron oxide staining, dry, no odor	X	1445			Recovery = 16/24 Blows: 4, 3, 6, 13
7								
8								
9								
10							210.1 10.0 2.4	
11			10-12' SAA except more calcite content	X	1500		211.7 9.7 2.1	Recovery: 24/24 Blows: 11, 26, 33, 48 BH = 2.6/2.6
12							212.2 11.0 2.1	BE = 2.6/2.6
13			12-13' SAA	X	1505		214.7 74.0 2.1	Recovery = 24/24 Blows: 9, 16, 19, 29
14			13-14' Clay, sm silty, brn, tr. calcite, iron oxide staining, moist, no odor, no sm blk staining	X				
15			14-14.5' SAA 10-12' interval, except moist	X	1515		216.7 27.4 2.4	Recovery: 24/24 BH = 2.9/2.9
16			14.5-16' Clay, silty, very brittle, calcite crystals very prevalent, v moist, brn w/ blk staining, sl pet. odor	X			217.9 42.9 5.0	BE = 2.9/2.9 Blows: 6, 10, 14, 18
17			16-18' SAA except less calcite & dry	X	1525		218.1 17.6 5.0	Recovery: 24/24 Blows: 7, 13, 18, 23
18								
19								
20			18-20' SAA (16-18' except no odor)	X	1535		220.1 17.8 5.0	Recovery: 24/24 BH 18.0/2.9 BE = 2.9/2.9 Blows: 10, 23, 34, 52

PID - Photoionization Detector

BH - Borehole

SAA - Same As Above

Bkgrnd - Background

HSA - Hollow Stem Auger

ft - Feet

bgs - Below Ground Surface

na - Not Analyzed

ppmv - Parts per Million, Volume per Volume

HS - Sample Headspace

SS - Split Spoon Sample

BS - Brass Sleeve Sample

G - Grab Sample

# GEOLOGIC BORING LOG

JOB NUMBER.: 726876.73330  
BORING NUMBER: 8200-MPF  
RIG TYPE: CMET5  
TEMPERATURE (°F): ~75°F

CLIENT: AFCEE/AEC/Ft. Carson  
BORING DIA.: 8"  
CONTRACTOR: Ground Exploration  
WEATHER: clear, S breeze from east  
DRLG MED: Solid stem sugar

DATE: 7/24/96  
ELEVATION: \_\_\_\_\_  
DATUM: \_\_\_\_\_  
GEOLOGIST: D. Teets

**COMMENTS:**

Depth (ft.)	Pro- file	USCS	Geologic Description	Split Spoon Interval	Laboratory Sample Identification	Sample Type	PID ppmv	Remarks
1								
2								
3								
4			4-5.3' Clay, silty, relatively loose, brn/	X	1030	SS	e6' 11.0 2.4	Recovery = 19/24 Blows = 4, 5, 6, 7
5			iron oxide staining, moist, no petroleum	I				
6			odor or staining					
7								
8								
9			9-11' Clay, silty, stiff, brittle, brn/	X	1045	SS	e11' 11.0 2.5	Recovery = 24/24 Blows = 16, 32, 43, 55
10			dark brn intervals, sm calcite present,	X				
11			iron oxide staining, dry, no petroleum	X	1055	SS	e17' 29.7 2.4	Recovery = 24/24 BH = 2.9/2.9 BZ = 2.9/2.9
12			odor	X				
13			11-12.5' SAA, except more calcite content	X				
14			12.5-13' Clay, sm silty, lt brn, tr calcite,	X	1110		e15' 46.0 2.4	Recovery = 24/24 Blows = 12, 19, 22, 26
15			iron oxide staining, moist, no odor or staining	X				
16			13-15' Clay, silty, stiff, brittle, brn/dk	X	1115		e17' 49.2 2.4	Recovery = 24/24 Blows = 11, 16, 22, 25
17			brn-black intervals, sm calcite present	X				
18			iron oxide staining, dry, no odor	X				
19			15-17' SAA	X	1130		e19' 19.6 2.1	Recovery = 24/24 BH = 2.10/2.9 BZ = 2.9/2.9
20			17.0-17.5' SAA except sm tan soil, wet	X				
			17.5-19' Clay, silty, stiff, brittle, brn/	X				
			dk brn-black intervals, sm calcite present,	X				
			iron oxide staining, dry, no odor	X				
			TD = 19.0' bgs					

**PID - Photoionization Detector**

BH - Borehole

SAA - Same As Above

### Bkgrnd - Background

**HSA - Hollow Stem Auger**

ft - Feet

bgs - Below Ground Surface

na - Not Analyzed

ppmv - Parts per Million, Volume per Volume

HS - Sample Headspace

SS - Split Spoon Sample

BS - Brass Sleeve Sample

**G - Grab Sample**



## GEOLOGIC BORING LOG

JOB NUMBER: 726876.73330 CLIENT: AFCEE/AEC/Ft. Carson DATE: 07/26/96  
 BORING NUMBER: 8200-~~YWS~~ ~~MPG~~ BORING DIA.: 11-inch 2-inch ELEVATION: \_\_\_\_\_  
 RIG TYPE: Geoprobe CONTRACTOR: Ground Exploration Parsons ES DATUM: \_\_\_\_\_  
 TEMPERATURE (°F): BOPF WEATHER: \_\_\_\_\_ GEOLOGIST: D. Teets  
 DRLG MED: HSA Direct push

COMMENTS:

Depth (ft.)	Pro- file	USCS	Geologic Description	Split Spoon Interval	Laboratory Sample Identification	Sample Type	PID ppmv	Remarks
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12			tr. sand f				12 15.5 4.7	
13			12-13.0': Clay, drk brn, v dense, no odor or staining	X			13 18.6 2.6	
14			13.0-13.5: Silt, sandy, fec, sm clay, tr gravel, brn, dry, no odor or staining	X			15' 10.2 2.9	
15			14-15': Clay, silty, sm calcite, dry, drk brn, no odor or staining	X			18' 18.6 8.0	
16			16-18'	X			19.5 716 7.7	
17			16-18': Clay, sm calcite, moist, brn, no odor or staining	X			22 67.2/4.5	
18			18-19 SAA	X				
19			19-19.5 SAA except blk staining & pet. odor present, v moist	X				
20			20-22' Clay, sm calcite, moist, brn, slight odor no staining					

PID - Photoionization Detector

BH - Borehole

SAA - Same As Above

Bkgrnd - Background

HSA - Hollow Stem Auger

ft - Feet

bgs - Below Ground Surface

na - Not Analyzed

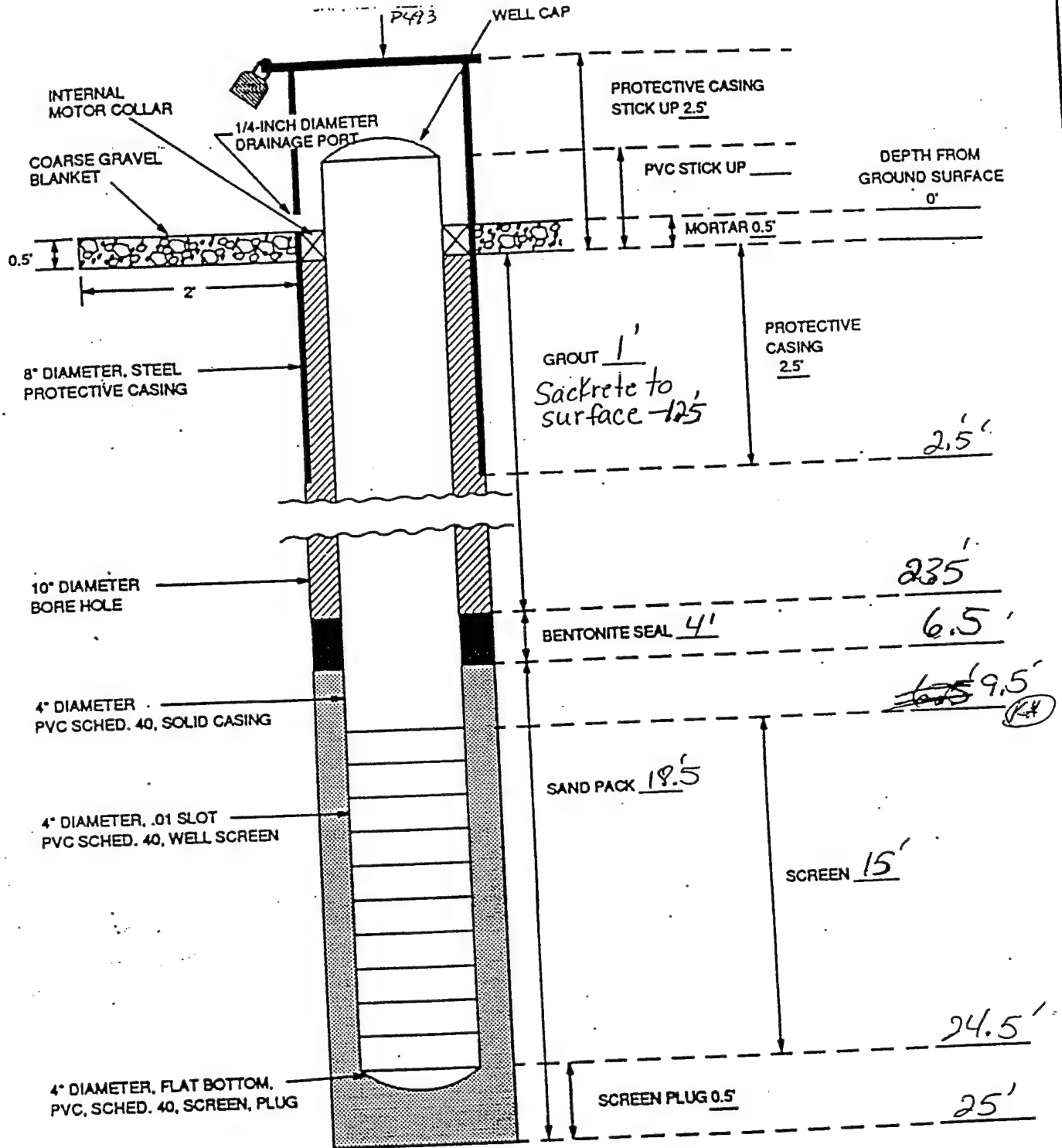
ppmv - Parts per Million, Volume per Volume

HS - Sample Headspace

SS - Split Spoon Sample

BS - Brass Sleeve Sample

G - Grab Sample



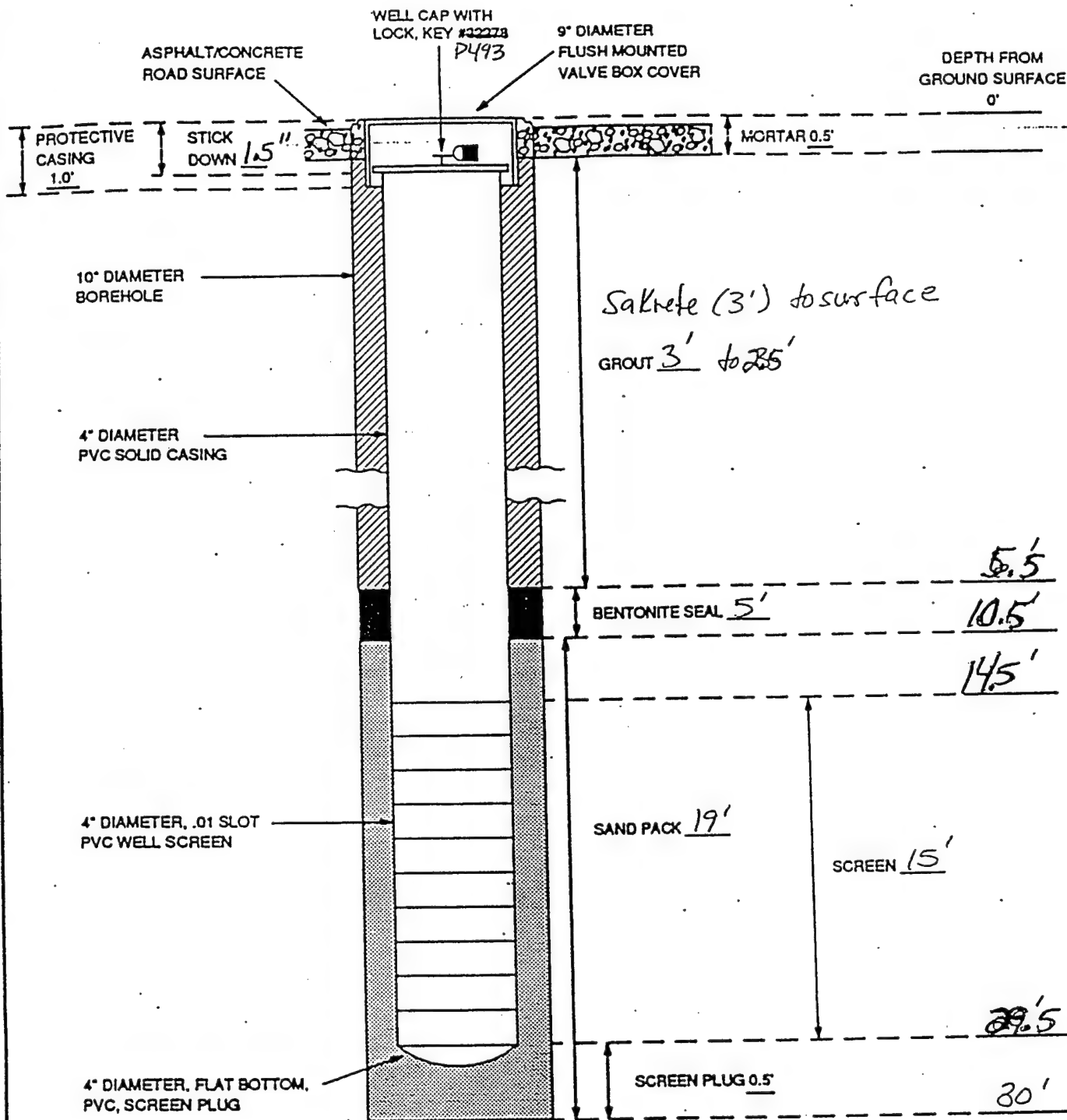
**WELL CONSTRUCTION DIAGRAM  
ABOVE GROUND GROUNDWATER MONITORING WELL**

SITE: FORT CARSON  
DATE START: 7-21-92  
TOTAL DEPTH: 25'

WELL NUMBER: ~~FCMW-89~~ FCMW-89  
DATE FINISH: 7-22-92  
GEOLOGIST: K. Hanson

NOT TO SCALE

Bldg. 8200



**WELL CONSTRUCTION DIAGRAM  
FLUSH MOUNT GROUNDWATER MONITORING WELL**

**SITE:** FORT CARSON  
**DATE START:** 7-21-92  
**TOTAL DEPTH:** 30'

**WELL NUMBER:** FCMW-88  
**DATE FINISH:** 7-22-92  
**GEOLOGIST:** K. Hanson

NOT TO SCALE

Bldg. 8200

# HTW DRILLING LOG

HOLE NO: 8200-HW1

1. COMPANY NAME <i>RUST Environment &amp; Infrastructure, Englewood, CO</i>		2. DRILLING SUBCONTRACTOR <i>Site Services Inc., Golden, CO</i>		SHEET 1 OF 2			
3. PROJECT <i>87533.200 Fort Carson - Multiple USTs</i>			4. LOCATION <i>Motor Pool #8200</i>				
5. NAME OF DRILLER <i>Anthony Rodriguez</i>			6. MANUFACTURER'S DESIGNATION OF DRILL <i>CME-75</i>				
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT	8" outside diameter		8. HOLE LOCATION <i>East of westernmost pump island</i>				
	Hollow Stem Auger						
	Continuous Core						
			9. SURFACE ELEVATION <i>5844.18</i> N: <i>76258.3349</i> E: <i>220552.4357</i>				
			10. DATE STARTED <i>June 29, 1994</i>				
12. OVERBURDEN THICKNESS: <i>20.0</i>			15. DEPTH GROUNDWATER ENCOUNTERED (in ft bgs) <i>9.0</i>				
13. DEPTH DRILLED INTO ROCK: <i>0.0</i>			16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED <i>9.06 7/20/94</i>				
14. TOTAL DEPTH OF HOLE (in ft bgs): <i>20.0</i>			17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)				
18. GEOTECHNICAL SAMPLES		DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES			
15-18, 10-13		X					
20. SAMPLES FOR CHEMICAL ANALYSIS		VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	
8-10, 10-13, 15-18		X	Total Pb/Cr	TCO	PCBs	Oil & Grease	
22. DISPOSITION OF HOLE		BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR		
G.M. Monitoring Well			8200-SB1		Ken Pili, Robin Christians		
DEPTH a	USCS b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	REMARKS g	MONITORING WELL DIAGRAM h
1	CL	10" Concrete at surface.	0 ppm			5 Sand 20 Silt 75 Clay	
2		Stiff, very dark grayish brown, SILTY CLAY, trace fine sand, slightly moist.					
3							
4							
5	ML	Soft, very dark grayish brown, SILTY CLAY, thinly laminated, slightly indurated, trace fine sand, trace clay, orange staining on fracture faces, moist.	895 ppm			Hydrocarbon odor starting at 5' bgs. 5 Sand 90 Silt 5 clay	
6							
7							
8							
9							

PROJECT *87533.200 Fort Carson - Multiple USTs*

HOLE NO. 8200-HW1

# HTW DRILLING LOG

HOLE NO: 8200-MW1

PROJECT 87533.200 Fort Carson - Multiple USTs

INSPECTOR

SHEET 2 OF 2 SHEET (S)

DEPTH a	USCS b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	REMARKS g	WELL DIAGRAM h
11	CH	Medium stiff, dark gray (10 YR 4/1), SILTY CLAY, moist.					
12		SILTY CLAY, orange staining, gypsum, strong odor.	1000+ ppm	10'-13'	8200-SB1 10'-13'	0 Sand 20 Silt 80 Clay  Strong hydrocarbon odor, staining.	
13							
14		Blocky fractures with product between fractures.	1000+ ppm				
15	CL					Strong odor, possible product.	
16		Soft, light yellowish brown (10 YR 8/4), SILTY CLAY, few fine-to coarse-grained sand, moist.	1000+ ppm	15'-18'	8200-SB1 15'-18'		
17							
18			1000+ ppm				
19							
20		TOTAL DEPTH = 20 FEET BGS					
21							
22							
23							
24							
25							
26							
27							
28							
29							

PROJECT 87533.200  
Fort Carson - Multiple USTs

HOLE NO. 8200-MW1

# HTW DRILLING LOG

HOLE NO: 8200-MW2

1. COMPANY NAME *RUST Environment & Infrastructure, Englewood, CO*

2. DRILLING SUBCONTRACTOR *Site Services Inc., Golden, CO*

SHEET 1 OF 2

3. PROJECT *87533.200 Fort Carson - Multiple USTs*

4. LOCATION *Motor Pool #8200*

5. NAME OF DRILLER *Anthony Rodriguez*

6. MANUFACTURER'S DESIGNATION OF DRILL *CME-75*

7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT

*8" outside diameter*

*Hollow Stem Auger*

*Continuous Core*

8. HOLE LOCATION *West of easternmost pump island*

9. SURFACE ELEVATION *5843.98* N: *762154.5619* E: *2205691.9133*

10. DATE STARTED *July 5, 1994*

12. OVERBURDEN THICKNESS: *18.5*

15. DEPTH GROUNDWATER ENCOUNTERED (in ft. bgs) *10*

13. DEPTH DRILLED INTO ROCK: *0.0*

16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED *9.18 7/20/94*

14. TOTAL DEPTH OF HOLE (in ft. bgs): *18.5*

17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) *NA*

18. GEOTECHNICAL SAMPLES

DISTURBED

UNDISTURBED

19. TOTAL NUMBER OF CORE BOXES

*5-8, 10-13*

*X*

20. SAMPLES FOR CHEMICAL ANALYSIS

VOC

METALS

OTHER (SPECIFY)

OTHER (SPECIFY)

OTHER (SPECIFY)

21. TOTAL CORE RECOVERY

*5-8, 8-10, 10-13*

*X*

*Total Pb/Cr*

*TCO*

*PCBs*

*Oil & Grease*

*100 %*

22. DISPOSITION OF HOLE

BACKFILLED

MONITORING WELL

OTHER (SPECIFY)

23. SIGNATURE OF INSPECTOR

*G.N. Monitoring Well*

*8200-MW2*

*Ken P.M., Robin Christians*

DEPTH a	USCS b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	REMARKS g	MONITORING WELL DIAGRAM h
1	ML	12" Concrete at surface	0 ppm			Hydrocarbon staining and odors at 2'.	
2		Stiff, dark brown, SILTY CLAY, iron staining, calcite present, dry.	0 ppm			80% Recovery 60 Silt 35 Clay 5 Sand	
3							
4							
5							
6		Very stiff, dark brown, SILTY CLAY, iron staining, calcite present, dry.	0 ppm	5'- 8'	8200-SB2 5'- 8'		
7							
8						100% Recovery 55 Silt 45 Clay 5 Sand	
9					8200-SB2 8'-10'		

PROJECT *87533.200 Fort Carson - Multiple USTs*

HOLE NO. *8200-MW2*

# HTW DRILLING LOG

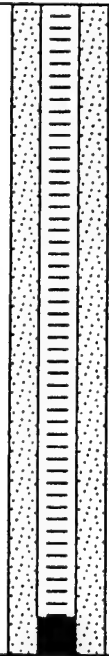
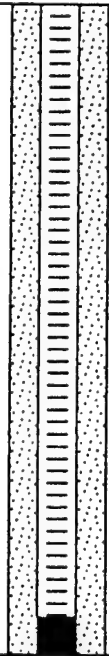
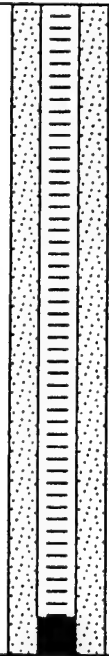
HOLE NO: 8200-MW2

PROJECT 87533.200 Fort Carson - Multiple USTs

INSPECTOR

SHEET 2 OF 2 SHEET (S)

SHEET 1 OF 2 SHEET (3)

DEPTH a	USCS b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	REMARKS g	WELL DIAGRAM h
11	ML	Stiff to firm, dark brown, SILTY CLAY, iron staining, slightly moist.	0 ppm	10' - 13'	8200-SB2 10' - 13'		
12		Very moist at 11.5' (2" layer)					
13	CL	Very soft, dark brown, SILTY CLAY, iron staining, fractured, saturated.	0 ppm				
14							
15			0 ppm				
16		Stiff, dark brown, SILTY CLAY, iron staining.					
17							
18							
19	TOTAL DEPTH = 18.5 FEET BGS						
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							

PROJECT 87533.200  
Fort Carson - Multiple USTs

HOLE NO. 8200-MW2

# HTW DRILLING LOG

HOLE NO: 8200-MM3

1. COMPANY NAME *RUST Environment & Infrastructure, Englewood, CO*

2. DRILLING SUBCONTRACTOR *Site Services Inc., Golden, CO*

SHEET 1 OF 2

3. PROJECT *87533.200 Fort Carson - Multiple USTs*

4. LOCATION *Motor Pool #8200*

5. NAME OF DRILLER *Anthony Rodriguez*

6. MANUFACTURER'S DESIGNATION OF DRILL *CME-75*

7. SIZES AND TYPES OF  
DRILLING AND SAMPLING  
EQUIPMENT

*8" outside diameter*

*Hollow Stem Auger*

*Continuous Core*

8. HOLE LOCATION *North of easternmost pump island*

9. SURFACE ELEVATION *5844.72* N: *7628914033* E: *22057428853*

10. DATE STARTED *July 5, 1994*

12. OVERBURDEN THICKNESS: *15.0*

15. DEPTH GROUNDWATER ENCOUNTERED (in ft bgs) *9.0*

13. DEPTH DRILLED INTO ROCK: *0.0*

16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED *9.06 7/21/94*

14. TOTAL DEPTH OF HOLE (in ft bgs): *15.0*

17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) *NA*

18. GEOTECHNICAL SAMPLES

*5-8, 10-13*

DISTURBED

*X*

UNDISTURBED

19. TOTAL NUMBER OF CORE BOXES

20. SAMPLES FOR CHEMICAL ANALYSIS

*3-8, 8-13*

VOC

*X*

METALS

Total Pb/Cr

OTHER (SPECIFY)

TCO

OTHER (SPECIFY)

PCBs

OTHER (SPECIFY)

Oil & Grease

21. TOTAL CORE RECOVERY

*100 %*

22. DISPOSITION OF HOLE

*G.W. Monitoring Well*

BACKFILLED

MONITORING WELL

*8200-MM3*

OTHER (SPECIFY)

23. SIGNATURE OF INSPECTOR

*Ken Pili, Robin Christians*

DEPTH a	USCS b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	REMARKS g	MONITORING WELL DIAGRAM h
1		14" Concrete at surface.	0 ppm				
2							
3						100% Recovery	
4		Very stiff, dark brown, SILTY CLAY, with gypsum veins continuous through core, dry.	0 ppm				
5	CL						
6			0 ppm				
7				5'-8'			
8						100 % Recovery	
9		Very stiff SILTY CLAY with pebble size gypsum crystals continuous through core, dry, hydrocarbon staining/odor, fractured.	0 ppm		8200-SB3 8'-10'		

PROJECT *87533.200 Fort Carson - Multiple USTs*

HOLE NO. 8200-MM3



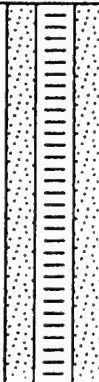
# HTW DRILLING LOG

HOLE NO: 8200-MW3

PROJECT 87533.200 Fort Carson - Multiple USTs

INSPECTOR

SHEET 2 OF 2 SHEET (S)

DEPTH a	USCS b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	REMARKS g	WELL DIAGRAM h
11	CL	Very stiff, dark brown/black, SILTY CLAY with coarse-sand size gypsum crystals continuous throughout core, hydrocarbon staining continuous through core, saturated, fractured.	0 ppm	10'-13'	8200-SB3 10'-13'	95 Silt/Clay 5 Sand	
12							
13		Stiff, dark brown/black, SILTY CLAY, hydrocarbon staining continuous through core, saturated.	0 ppm		8200-SB3 13'-15'		
14							
15		TOTAL DEPTH = 15 FEET BGS					
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							

PROJECT 87533.200  
Fort Carson - Multiple USTs

HOLE NO. 8200-MW3

# HTW DRILLING LOG

HOLE NO: 8200-MW4

1. COMPANY NAME *RUST Environment & Infrastructure, Englewood, CO*

2. DRILLING SUBCONTRACTOR *Site Services Inc., Golden, CO*

SHEET 1 OF 2

3. PROJECT *87533.200 Fort Carson - Multiple USTs*

4. LOCATION *Motor Pool #8200*

5. NAME OF DRILLER *Anthony Rodriguez*

6. MANUFACTURER'S DESIGNATION OF DRILL *CME-75*

7. SIZES AND TYPES OF  
DRILLING AND SAMPLING  
EQUIPMENT

*8" outside diameter*

*Hollow Stem Auger*

*Continuous Core*

8. HOLE LOCATION *North of fence, east of tanks.*

9. SURFACE ELEVATION *5846.79* N: *762273.6003* E: *2205676.5415*

10. DATE STARTED *July 6, 1994*

12. OVERBURDEN THICKNESS: *15.0*

15. DEPTH GROUNDWATER ENCOUNTERED (in ft. bgs) *9.5*

13. DEPTH DRILLED INTO ROCK: *0.0*

16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED *14.21 7/22/94*

14. TOTAL DEPTH OF HOLE (in ft. bgs): *15.0*

17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) *NA*

18. GEOTECHNICAL SAMPLES

*5-8, 10-13*

DISTURBED

*X*

UNOISTURBED

19. TOTAL NUMBER OF CORE BOXES

20. SAMPLES FOR CHEMICAL ANALYSIS

*8-10, 10-13, 13-15*

VOC

*X*

METALS

*Total Pb/Cr*

OTHER (SPECIFY)

*TCO*

OTHER (SPECIFY)

*PCBs*

OTHER (SPECIFY)

*Oil & Grease*

21. TOTAL CORE  
RECOVERY

*100 %*

22. DISPOSITION OF HOLE

*G.W. Monitoring Well*

BACKFILLED

MONITORING WELL

*8200-MW4*

OTHER (SPECIFY)

23. SIGNATURE OF INSPECTOR

*Ken Pihl, Robin Christians*

DEPTH a	USCS b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	REMARKS g	MONITORING WELL DIAGRAM h
-4							
-3							
-2							
-1							
0		Topsoil and cobbles	0 ppm				
1							
2	CL						
3		Very stiff, dark brown, SILTY CLAY, gypsum present, slightly moist.	0 ppm			100% Recovery 10 Sand 40 Silt 50 Clay	
4							

PROJECT *87533.200*  
*Fort Carson - Multiple USTs*

HOLE NO. *8200-MW4*

# HTW DRILLING LOG

HOLE NO: 8200-MW4

PROJECT 87533.200 Fort Carson - Multiple USTs

INSPECTOR

SHEET 2 OF 2 SHEET (S)

SHEET 2 OF 2 SHEET(S)							
DEPTH a	USCS b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	REMARKS g	WELL DIAGRAM h
6	CL	CLAY, as above, except moist.  Very stiff/hard, dark brown, SILTY CLAY, gypsum present continuous through core, dry.  Very hard, dark brown SILTY CLAY, iron staining, gypsum present, very moist.  Hard, dark brown/black, SILTY CLAY, weathered, iron staining, saturated.	0 ppm	5'- 8'			
7							
8			0 ppm		8200-SB4 8'-10'	5 Sand 35 Silt 60 Clay	
9							
10			0 ppm		8200-SB4 10'-13'	40 Silt 5 Sand 35 Clay	
11							
12							
13			0 ppm			100% Recovery 40 Silt 5 Sand 55 Clay	
14					8200-SB4 13'-15'		
15	TOTAL DEPTH = 15 FEET BGS						
16							
17							
18							
19							
20							
21							
22							
23							
24							

PROJECT 87533.200  
Fort Carson - Multiple USTs

HOLE NO. 8200-MW4

# HTW DRILLING LOG

HOLE NO: 8200-MW5

1. COMPANY NAME *RUST Environment & Infrastructure, Englewood, CO*

2. DRILLING SUBCONTRACTOR *Site Services Inc., Golden, CO*

SHEET 1 OF 2

3. PROJECT *87533.200 Fort Carson - Multiple USTs*

4. LOCATION *Motor Pool #8200*

5. NAME OF DRILLER *Anthony Rodriguez*

6. MANUFACTURER'S DESIGNATION OF DRILL *CHE-75*

7. SIZES AND TYPES OF  
DRILLING AND SAMPLING  
EQUIPMENT

*8" outside diameter*

*Hollow Stem Auger*

*Continuous Core*

8. HOLE LOCATION *Northwest of USTs*

9. SURFACE ELEVATION *5848.23* N: *762327.3746* E: *2205505.0599*

10. DATE STARTED *July 6, 1994*

12. OVERBURDEN THICKNESS: *20.0*

15. DEPTH GROUNDWATER ENCOUNTERED (in ft. bgs) *18.5*

13. DEPTH DRILLED INTO ROCK: *0.0*

16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED *20.59 7/28/94*

14. TOTAL DEPTH OF HOLE (in ft. bgs): *20.0*

17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) *NA*

18. GEOTECHNICAL SAMPLES

DISTURBED

UNDISTURBED

19. TOTAL NUMBER OF CORE BOXES

*5-8, 10-13*

*X*

20. SAMPLES FOR CHEMICAL ANALYSIS

VOC

METALS

OTHER (SPECIFY)

OTHER (SPECIFY)

OTHER (SPECIFY)

21. TOTAL CORE RECOVERY

*8-10, 10-13, 15-18*

*X*

*Total Pb/Cr*

*TCO*

*PCBs*

*Oil & Grease*

*100 %*

22. DISPOSITION OF HOLE

BACKFILLED

MONITORING WELL

OTHER (SPECIFY)

23. SIGNATURE OF INSPECTOR

*G.M. Monitoring Well*

*8200-MW5*

*Ken PIM, Robin Christians*

DEPTH a	USCS b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	REMARKS g	MONITORING WELL DIAGRAM h
-4							
-3							
-2							
-1							
0		Topsoil and cobbles.	0 ppm				
1							
2	CL						
3		Hard, dark brown, SILTY CLAY; iron staining, dry.	0 ppm			100% Recovery 20 Sand 30 Silt 50 Clay	
4							

PROJECT *87533.200 Fort Carson - Multiple USTs*

HOLE NO. 8200-MW5

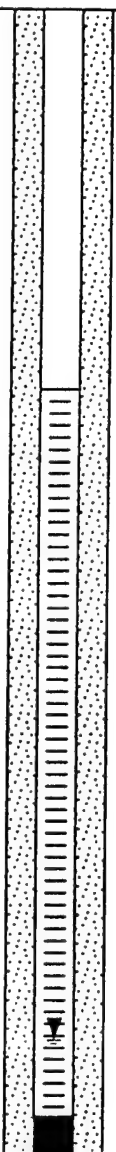
# HTW DRILLING LOG

HOLE NO. 8200-MW5

PROJECT 87533.200 Fort Carson - Multiple USTs

INSPECTOR

SHEET 2 OF 2 SHEET (S)

INSPECTION								SHEET 2 OF 2 SHEET (S)	
DEPTH a	USCS b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	REMARKS g	WELL DIAGRAM h		
6	CL	Hard, dark brown, SILTY CLAY, iron staining, dry.	0 ppm	5'- 8'		80 Silt/Clay 20 Sand			
7									
8									
9			0 ppm		8200-SB5 8'-10'				
10									
11			0 ppm	10'- 13'	8200-SB5 10'-13'	30 Silt 20 Sand 50 Clay			
12									
13			Very stiff, dark brown, SILTY CLAY, fractured, dry, iron staining continues, calcareous veining present.	0 ppm					100% Recovery 45 Silt 5 Sand 50 Clay
14									
15			Very stiff, medium gray, CLAY, possible bentonite, slightly moist.						
16		Very stiff, dark brown, SILTY CLAY, slightly moist, calcareous veining.							
17				8200-SB5 15'-18'					
18			0 ppm			10 Sand 30 Silt 60 Clay			
19		Soft, dark brown, SILTY CLAY, very moist to saturated, calcareous veining.	0 ppm						
20		TOTAL DEPTH = 20 FEET BGS							
21									
22									
23									
24									

PROJECT 87533.200  
Fort Carson - Multiple USTs

HOLE NO. 8200-MW5

<b>HTW DRILLING LOG</b>							HOLE NO: 8200-SB8
1. COMPANY NAME <i>RUST Environment &amp; Infrastructure, Englewood, CO</i>				2. DRILLING SUBCONTRACTOR <i>Site Services Inc., Golden, CO</i>		SHEET 1 OF 2	
3. PROJECT <i>87533.200 Fort Carson - Multiple USTs</i>				4. LOCATION <i>Motor Pool #8200</i>			
5. NAME OF DRILLER <i>Anthony Rodriguez</i>				6. MANUFACTURER'S DESIGNATION OF DRILL <i>CHE-75</i>			
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT		<div style="border: 1px solid black; padding: 2px;">8" outside diameter</div> <div style="border: 1px solid black; padding: 2px;">Hollow Stem Auger</div> <div style="border: 1px solid black; padding: 2px;">Continuous Core</div>		8. HOLE LOCATION <i>Immediately south of tanks.</i>			
				9. SURFACE ELEVATION <i>5844.73</i>		N: <i>762196.9835</i> E: <i>2205562.2940</i>	
				10. DATE STARTED <i>July 7, 1994</i>			
12. OVERBURDEN THICKNESS: <i>11.0</i>				15. DEPTH GROUNDWATER ENCOUNTERED (in ft bgs) <i>8'-8.5'</i>			
13. DEPTH DRILLED INTO ROCK: <i>2.0</i>				16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED <i>NA</i>			
14. TOTAL DEPTH OF HOLE (in ft bgs): <i>13.0</i>				17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) <i>NA</i>			
18. GEOTECHNICAL SAMPLES		DISTURBED		UNDISTURBED		19. TOTAL NUMBER OF CORE BOXES	
NA							
20. SAMPLES FOR CHEMICAL ANALYSIS		VOC		METALS		OTHER (SPECIFY)	
5-8, 8-10, 10-13		X		Total Pb/Cr		TCO	
						PCBs	
						Oil & Grease	
22. DISPOSITION OF HOLE		BACKFILLED		MONITORING WELL		23. SIGNATURE OF INSPECTOR	
		X				Ken Pill, Robin Christians	
DEPTH a	USCS b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1		Concrete at surface.					
2		Soft, dark brown, SILTY CLAY, occasional calcareous veining, occasional gypsum crystals, iron staining, weathered, slightly moist, fractured.					
3							
4							
5	CL		0 ppm				
6			0 ppm		8200-SB8 5'-8'		15 Sand 35 Silt 50 Clay
7							
8			0 ppm				
9		Stiff, dark brown, SILTY CLAY, gypsum, iron staining, slightly moist.			8200-SB8 8'-10'		10 Sand 45 Silt 45 Clay

PROJECT 87533.200  
Fort Carson - Multiple USTs

HOLE NO. 8200-SB8

# HTW DRILLING LOG

HOLE NO: 8200-SB8

PROJECT 87533.200 Fort Carson - Multiple USTs

INSPECTOR

SHEET 2 OF 2 SHEET (S)

DEPTH a	USCS b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
11	CL	Stiff, medium tan, CLAY (bentonitic?), slightly moist.	0 ppm		8200-SB8 10'-13'		
12	SHst	Hard, dark brown, SILTSTONE, calcite veining continuous throughout core, moist to dry.					
13	TOTAL DEPTH = 13 FEET BGS						
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							

PROJECT 87533.200  
Fort Carson - Multiple USTs

HOLE NO. 8200-SB8

# HTW DRILLING LOG

HOLE NO: 8200-SB7

1. COMPANY NAME *RUST Environment & Infrastructure, Englewood, CO*

2. DRILLING SUBCONTRACTOR *Site Services Inc., Golden*

SHEET 1 OF 2

3. PROJECT *87533.200 Fort Carson - Multiple USTs*

4. LOCATION *Motor Pool #8200*

5. NAME OF DRILLER *Anthony Rodriguez*

6. MANUFACTURER'S DESIGNATION OF DRILL *CME-75*

7. SIZES AND TYPES OF  
DRILLING AND SAMPLING  
EQUIPMENT

*8" outside diameter*

*Hollow Stem Auger*

*Continuous Core*

8. HOLE LOCATION *Northeast of tanks.*

9. SURFACE ELEVATION *5845.62* N: *762243.811* E: *2205678.3959*

10. DATE STARTED *July 7, 1994*

12. OVERBURDEN THICKNESS: *11.5*

15. DEPTH GROUNDWATER ENCOUNTERED (in ft bgs) *8.0*

13. DEPTH DRILLED INTO ROCK: *1.5*

16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED *NA*

14. TOTAL DEPTH OF HOLE (in ft bgs): *13.0*

17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) *NA*

18. GEOTECHNICAL SAMPLES

DISTURBED

UNDISTURBED

19. TOTAL NUMBER OF CORE BOXES

20. SAMPLES FOR CHEMICAL ANALYSIS

VOC

METALS

OTHER (SPECIFY)

OTHER (SPECIFY)

OTHER (SPECIFY)

21. TOTAL CORE  
RECOVERY

*NA*

*X*

Total Pb/Cr

TCO

PCBs

Oil & Grease

*100 %*

22. DISPOSITION OF HOLE

BACKFILLED

MONITORING WELL

OTHER (SPECIFY)

23. SIGNATURE OF INSPECTOR

*X*

*Ken PM, Robin Christians*

DEPTH a	USCS b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
		Gravel at surface.					
1	ML	Soft, dark brown (7.5 YR 3/2), CLAYEY SILT, few % clay, blocky fractures, stains on faces, gypsum present, slightly indurated, slightly moist.	0 ppm				
2							
3							
4							
5							
6		8200-SB7 5'-8'					
7							
8		Hard, very dark gray (7.5 YR 3/0), CLAYEY SILT, blocky fractures with THW laminations, orange stained on fracture faces, gypsum crystals along fractures, indurated, moist.	0 ppm		8200-SB7 8'-10'		
9							

PROJECT *87533.200  
Fort Carson - Multiple USTs*

HOLE NO. 8200-SB7



# HTW DRILLING LOG

HOLE NO: 8200-SB7

PROJECT 87533.200 Fort Carson - Multiple USTs

INSPECTOR

SHEET 2 OF 2 SHEET (S)

DEPTH a	USCS b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
11	ML	Soft, strong brown (7.5 YR 5/8), SILTY CLAY, trace fine- to medium-grained sand, wet.					
12	Siltst	SILTSTONE, saturated at 11.5' bgs.	0 ppm		8200-SB7 10'-13'		
13		TOTAL DEPTH = 13 FEET BGS					
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							

PROJECT 87533.200  
Fort Carson - Multiple USTs

HOLE NO. 8200-SB7

# HTW DRILLING LOG

HOLE NO: 8200-SB8

1. COMPANY NAME *RUST Environment & Infrastructure, Englewood, CO*

2. DRILLING SUBCONTRACTOR *Site Services Inc., Golden, CO*

SHEET 1 OF 2

3. PROJECT *87533.200 Fort Carson - Multiple USTs*

4. LOCATION *Motor Pool #8200*

5. NAME OF DRILLER *Anthony Rodriguez*

6. MANUFACTURER'S DESIGNATION OF DRILL *CME-75*

7. SIZES AND TYPES OF  
DRILLING AND SAMPLING  
EQUIPMENT

*8" outside diameter*

*Hollow Stem Auger*

*Continuous Core*

8. HOLE LOCATION *50' west of MW-1*

9. SURFACE ELEVATION *5845.27*

*N: 762150.0683*

*E: 2205483.7979*

10. DATE STARTED *July 14, 1994*

12. OVERBURDEN THICKNESS: *12.0*

15. DEPTH GROUNDWATER ENCOUNTERED (in ft bgs)

13. DEPTH DRILLED INTO ROCK: *0.5*

16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED *NA*

14. TOTAL DEPTH OF HOLE (in ft bgs): *12.5*

17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) *NA*

18. GEOTECHNICAL SAMPLES

DISTURBED

UNDISTURBED

19. TOTAL NUMBER OF CORE BOXES

*NA*

20. SAMPLES FOR CHEMICAL ANALYSIS

VOC

METALS

OTHER (SPECIFY)

OTHER (SPECIFY)

OTHER (SPECIFY)

21. TOTAL CORE RECOVERY

*3*

*X*

*Total Pb/Cr*

*TCO*

*PCBs*

*Oil & Grease*

*100 %*

22. DISPOSITION OF HOLE

BACKFILLED

MONITORING WELL

OTHER (SPECIFY)

23. SIGNATURE OF INSPECTOR

*Vertical*

*X*

*Ken Pili, Robin Christians*

DEPTH a	USCS b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h	
1	CL	Concrete at surface.	0 ppm					
2								
3								
4		Firm, brown, CLAY with some silt, trace micaceous sand, some interbedded intervals of gravelly clay, moist, no hydrocarbon odor or staining.	0 ppm		8200-SB8 3'-4'			
5								
6								
7			0 ppm		8200-SB8 6'-7'			
8								
9		Firm, brown to dark brown, gravelly CLAY, moist.						

PROJECT 87533.200  
Fort Carson - Multiple USTs

HOLE NO. 8200-SB8

# HTW DRILLING LOG

HOLE NO: 8200-SB8

PROJECT 87533.200 Fort Carson - Multiple USTs

INSPECTOR

SHEET 2 OF 2 SHEET (S)

DEPTH a	USCS b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
11	CL	Firm, dark brown, gravelly CLAY, gravel is all shale, some large chert gravel, moist.	0 ppm				
12	SNSt	BEDROCK, dark brown, hard, shale.	0 ppm		8200-SB8 1f-12'		
13		TOTAL DEPTH = 12.5 FEET BGS.					
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							

PROJECT 87533.200  
Fort Carson - Multiple USTs

HOLE NO. 8200-SB8

# HTW DRILLING LOG

HOLE NO: 8200-SB9

1. COMPANY NAME *RUST Environment & Infrastructure, Englewood, CO*

2. DRILLING SUBCONTRACTOR *Site Services Inc., Golden, CO*

SHEET 1 OF 2

3. PROJECT *87533.200 Fort Carson - Multiple USTs*

4. LOCATION *Motor Pool #8200*

5. NAME OF DRILLER *Anthony Rodriguez*

6. MANUFACTURER'S DESIGNATION OF DRILL *CME-75*

7. SIZES AND TYPES OF  
DRILLING AND SAMPLING  
EQUIPMENT

*8" outside diameter*

*Hollow Stem Auger*

*Continuous Core*

8. HOLE LOCATION *40' southeast of easternmost dispenser island.*

9. SURFACE ELEVATION *5843.27*

*N: 782082.2559*

*E: 2205776.1440*

10. DATE STARTED *July 14, 1994*

12. OVERBURDEN THICKNESS: *5.0*

15. DEPTH GROUNDWATER ENCOUNTERED (in ft bgs)

13. DEPTH DRILLED INTO ROCK: *8.0*

16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED

14. TOTAL DEPTH OF HOLE (in ft bgs): *13.0*

17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)

18. GEOTECHNICAL SAMPLES

DISTURBED

UNDISTURBED

19. TOTAL NUMBER OF CORE BOXES

NA

20. SAMPLES FOR CHEMICAL ANALYSIS

VOC

METALS

OTHER (SPECIFY)

OTHER (SPECIFY)

OTHER (SPECIFY)

21. TOTAL CORE RECOVERY

*3-4, 8-9, 11-13*

*X*

*Total Pb/Cr*

*TCO*

*PCBs*

*Oil & Grease*

*100 %*

22. DISPOSITION OF HOLE

BACKFILLED

MONITORING WELL

OTHER (SPECIFY)

23. SIGNATURE OF INSPECTOR

*X*

*Ken Pill, Robin Christians*

DEPTH a	USCS b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1	CL	Concrete at surface.	0 ppm				
2							
3							
4		Firm, brown, SANDY CLAY, sand is micaceous, some calcite present, moist.	0 ppm		8200-SB9 3'- 4'		
5	SISL	- WEATHERED BEDROCK -  CLAYSTONE, hard, stratified, some iron staining, layering = 2mm thick.	0 ppm				
6							
7			0 ppm				
8					8200-SB9 8'- 9'		
9			0 ppm				

PROJECT *87533.200  
Fort Carson - Multiple USTs*

HOLE NO. 8200-SB9

# HTW DRILLING LOG

HOLE NO: 8200-SB9

PROJECT 87533.200 Fort Carson - Multiple USTs

INSPECTOR

SHEET 2 OF 2 SHEET (S)

DEPTH a	USCS b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
11	Silt	CLAYSTONE as above, except stratification not as evident, very moist at 13'.	0 ppm				
12		No odor or stain.	0 ppm		8200-SB9 12' - 13'		
13		TOTAL DEPTH = 13 FEET BGS					
14							
15							
16							
17							
18							
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23							
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25							
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28							
29							

PROJECT 87533.200  
Fort Carson - Multiple USTs

HOLE NO. 8200-SB9

# HTW DRILLING LOG

HOLE NO: 8200-SB10

1. COMPANY NAME *RUST Environment & Infrastructure, Englewood, CO*

2. DRILLING SUBCONTRACTOR *Site Services Inc., Golden, CO*

SHEET 1 OF 2

3. PROJECT *87533.200 Fort Carson - Multiple USTs*

4. LOCATION *Motor Pool #8200*

5. NAME OF DRILLER *Anthony Rodriguez*

6. MANUFACTURER'S DESIGNATION OF DRILL *CHE-75*

7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT

*8" outside diameter*

*Hollow Stem Auger*

*Continuous Core*

8. HOLE LOCATION *North of east building edge.*

9. SURFACE ELEVATION *5844.1752* N: *762216.6271* E: *2205788.7464*

10. DATE STARTED *July 25, 1994*

12. OVERBURDEN THICKNESS: *NA*

15. DEPTH GROUNDWATER ENCOUNTERED (in ft. bgs)

13. DEPTH DRILLED INTO ROCK: *NA*

16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED *10'-10.5' NA*

14. TOTAL DEPTH OF HOLE (in ft. bgs): *13.0*

17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY) *NA*

18. GEOTECHNICAL SAMPLES

DISTURBED

UNDISTURBED

19. TOTAL NUMBER OF CORE BOXES *NA*

20. SAMPLES FOR CHEMICAL ANALYSIS

VOC

METALS

OTHER (SPECIFY)

OTHER (SPECIFY)

OTHER (SPECIFY)

21. TOTAL CORE RECOVERY

*X*

22. DISPOSITION OF HOLE

BACKFILLED

MONITORING WELL

OTHER (SPECIFY)

23. SIGNATURE OF INSPECTOR

*Ken Pill, Robin Christians*

DEPTH a	USCS b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
1		Concrete at surface.	0 ppm				
2							
3			0 ppm				
4	CL	Firm, medium brown, SILTY CLAY with gypsum pockets, slightly moist.					Sand 15 Silt 35 Clay 50 80% Recovery
5							
6					8200-SB10 5'-8'		
7							
8			0 ppm				
9	ML	Firm to very firm, medium dark brown, SANDY SILT with gypsum pockets, slightly moist.			8200-SB10 8'-10'		Sand 25% Silt 45% Clay 30%

PROJECT *87533.200 Fort Carson - Multiple USTs*

HOLE NO. 8200-SB10

# HTW DRILLING LOG

HOLE NO: 8200-SB10

PROJECT 87533.200 Fort Carson - Multiple USTs

INSPECTOR

SHEET 2 OF 2 SHEET (S)

DEPTH a	USCS b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h
11	CL	Slightly soft, medium brown/organic, SILTY CLAY, hemantic staining, gypsum pockets, saturated at 10.5'.	0 ppm		8200-SB10 10'-13'		Sand 5% Silt 45% Clay 50%
12		Slightly firm, medium brown, SILTY CLAY, hemantic staining and gypsum pockets, no staining slightly moist, faint hydrocarbon odor at 13'.	25 ppm				Faint hydrocarbon odor at 13'; no visible staining.
13		TOTAL DEPTH = 13.0 FEET BGS					
14							
15							
16							
17							
18							
19							
20							
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27							
28							
29							

PROJECT 87533.200  
Fort Carson - Multiple USTs

HOLE NO. 8200-SB10

Report to:		Invoice to					
Company: <u>Parsons Engineering Science</u>		Company: _____					
Address: <u>1700 Broadway Ste 900</u>		Address: _____					
City: <u>Denver, CO 80290</u>		Contact: <u>Rob Riecken</u>					
Contact: <u>Dave Teets</u>		Phone: _____					
Phone: <u>(303) 831-8100</u>		POISO #: <u>726876.73330</u>					
Fax: <u>(303) 831-8208</u>							
Sampler's Name: <u>DAVID TEETS</u>		Sampler's Signature: <u>David Teets</u>					
Project Name: <u>AFCEE Bioventing - Fort Carson, Colo.</u>		No./Type of Containers <sup>2</sup>					
Matrix <sup>1</sup>	Date	Time	Identifying Marks of Sample(s)	VOA	AG 1 Lt.	250 ml	P/O
S	7/16/05	1055	X 8200-MPA-20				1
	7/16/05	1055	X 8200-MPB-21				1
	7/17/05	1050	X 8200-MPC-21				1
	7/23/05	1105	X 8200-MPD-19.5				2
	7/23/05	1555	X 8200-VW2-16				2
	7/23/06	1016	X 8200-MPD-9				1
	7/22/06	1345	X 8200-BG-11				1
	7/24/06	1110	X 8200-MPF-15				1
	7/24/06	1115	X 8200-MPF-17				2
	7/24/06	1525	X 8200-MPE-17.5				2

Analyses Requested	Lab Sample ID (Lab Use Only)
TKN only	8307-1
TKN, phosphorus	2
TKN, phosphorus, alkalinity, total iron	3
TKN, phosphorus, alkalinity, total iron	4
TKN, phosphorus, alkalinity, total iron	5
TKN, phosphorus, alkalinity, total iron	6
TKN, phosphorus, alkalinity, total iron	7
TKN, phosphorus, alkalinity, total iron	8
TKN, phosphorus, alkalinity, total iron	9
TKN, phosphorus, alkalinity, total iron	10

Lab use only	Due Date:		
Temp. of coolers when received (C°):			
2	3	4	5
Oustody Seal	N	Y	
Intact	N	Y	
Screened For Radioactivity			

Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:
<u>David Teets</u>	7/24/06	1900	<u>FED EX</u>	7/25/06	1625
Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:
			<u>B. N. N. N.</u>	7/25/06	1625
Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:

Remarks: OPTION 3 Reporting

Client's delivery of samples constitutes acceptance of Inchcape/ITS-Dallas terms and conditions contained in the Price Schedule.

SL - Sludge O - Oil C - Charcoal tube P/O - Plastic or other

W - Water S - Soil SD - Solid L - Liquid A - Air Bag 250 ml - Glass wide mouth A/G - Amber / Or Glass 1 Liter

WW - Wastewater VOA - 40 ml vial



# AIR TOXICS LTD.

AN ENVIRONMENTAL ANALYTICAL LABORATORY

180 BLUE RAVINE ROAD, SUITE B  
FOLSOM, CA 95630-4719  
(916) 985-1000 FAX: (916) 985-1020

## CHAIN-OF-CUSTODY RECORD

No 007721

Page 1 of 1

Contact Person Dave Treets  
Company Parsons Engineering Science Inc.  
Address 1700 Broadway Ste 900 City Denver State CO Zip 80202  
Phone (303) 831-8100 FAX (303) 831-8208  
Collected By: Signature \_\_\_\_\_

Project info:  
P.O. # 726876.73330  
Project # SAA  
Project Name Fort Carson Bioventing

Turn Around Time:

☒ Normal

☐ Rush \_\_\_\_\_ Specify \_\_\_\_\_

Lab I.D.	Field Sample I.D.	Date & Time	Analyses Requested	Canister Pressure / Vacuum
				Initial Final Receipt
01A	8200-VW2	7/25/96 0925	J0-3	4.5" Hg
02A	8200-MPD-18	7/25/96 1120		5.5" Hg
03A	FCMW89(VW1)	7/25/96 1420		5.5" Hg
04A	8200-MPD-10	7/25/96 1450		5.0" Hg
05A	8200-MW3	7/27/96 1330		6.0" Hg
06A	8200-MPF-12	7/30/96 1000		5.0" Hg
				8/2/96

Notes:

Four canisters returned that do not require analysis.

Relinquished By: (Signature) Dave Treets Date/Time 8/1/96 1500 Print Name DAVID TREETS  
Relinquished By: (Signature) \_\_\_\_\_ Date/Time \_\_\_\_\_  
Relinquished By: (Signature) \_\_\_\_\_ Date/Time \_\_\_\_\_

Relinquished By: (Signature) \_\_\_\_\_ Date/Time \_\_\_\_\_  
Received By: (Signature) Meredith Date/Time 8/2/96 1000

Shipper Name Fed-X Air Bill # 113181800 Opened By: TS Date/Time 8/2/96 1000 Condition Good Custody Seals Intact? Yes No None Work Order # 9608027  
Lab Use Only

**Initial Respiration Test  
Building 8200  
Fort Carson, Colorado**

Monitoring Point	Date	Days Elapsed (frac. days)	Time	Hrs elapsed (fractional days)	Days Elapsed	Elapsed Time (min. x 1000)	Elapsed Time (hours)	O2% CO2	Total Hydro-carbon	Helium (%)	Comments	Trend of O2/Time	New x-values	k (%/minute)	k (%/hour)
MPD-10	07/26/96	0.00	08:30	0.00	0.00	0.00	0.00	20.8	0.05	0	1 min. purge. Helium detector battery low	19.6856136	0	0.000442	0.026542
MPD-10	07/26/96	0.00	09:15	0.03	0.03	0.05	0.75	20.2	0.10	0		13.2402291	14.57		
MPD-10	07/26/96	0.00	11:45	0.14	0.14	0.20	3.25	19.9	0.20	0					
MPD-10	07/26/96	0.00	16:25	0.33	0.33	0.48	7.92	19.2	1.0	0					
MPD-10	07/27/96	1.00	09:10	0.03	1.03	1.48	24.67	18.5	0.95	0	4.7 2 min purge.				
MPD-10	07/27/96	1.00	15:05	0.27	1.27	1.84	30.58	18.4	1.2	0	Unable to collect sample in desiccator. Sample from pump				
MPD-10	07/28/96	2.00	10:35	0.09	2.09	3.01	50.08	18.8	1.1	0	3.7 offgas, in Tedlar.				
MPD-10	07/29/96	3.00	08:40	0.01	3.01	4.33	72.17	18.1	1.2	0	2.7 SAA. Took 5 min to fill bag				
MPD-10	07/29/96	3.00	19:45	0.47	3.47	5.00	83.25	16.7	1.6	0	3.4 SAA				
MPD-10	07/30/96	4.00	08:55	0.02	4.02	5.79	96.42	15.7	2.0	0	NS SAA				
MPD-10	08/05/96	10.00	11:20	0.12	10.12	14.57	242.83	14.0	1.8	0	4.9 SAA				
MPD-10	08/05/96	10.00	11:20	0.12	10.12	14.57	242.83	14.0	1.8	0	NS Very "tight", little sample				
MPD-18	07/26/96	0.00	08:33	0.00	0.00	0.00	0.00	20.8	0.05	2	1 min. purge. Helium detector battery low	20.3320193	0	0.000773	0.046410
MPD-18	07/26/96	0.00	09:20	0.03	0.03	0.05	0.78	20.6	0.15	100		9.06988728	14.56		
MPD-18	07/26/96	0.00	11:50	0.14	0.14	0.20	3.28	20.3	0.35	320					
MPD-18	07/26/96	0.00	16:31	0.33	0.33	0.48	7.97	20.1	1.0	540					
MPD-18	07/27/96	1.00	09:15	0.03	1.03	1.48	24.70	18.8	1.5	1,100	1.00 2 min purge.				
MPD-18	07/27/96	1.00	15:10	0.28	1.28	1.84	30.62	18.7	1.8	1,250	4.5 SAA				
MPD-18	07/28/96	2.00	10:05	0.06	2.06	2.97	49.53	17.9	2.0	1,600	5.9 SAA				
MPD-18	07/28/96	2.00	15:55	0.31	2.31	3.32	55.37	17.6	2.2	1,800	5.6 SAA				
MPD-18	07/29/96	3.00	08:15	-0.01	2.99	4.30	71.70	16.7	2.6	2,300	8.9 SAA				
MPD-18	07/29/96	3.00	19:35	0.46	3.46	4.98	83.03	16.3	2.6	2,500	8.6 SAA				
MPD-18	07/30/96	4.00	08:25	-0.01	3.99	5.75	95.87	16.0	2.8	2,700	9.7 SAA				
MPD-18	08/05/96	10.00	11:10	0.11	10.11	14.56	242.62	9.3	3.4	2,400	10.0 SAA				
MPG-13	07/28/96	0.00	10:00	0.00	0.00	0.00	0.00	20.7	0.1	16	NS 1 min. purge	20.4888544	0	0.000217	0.013033
MPG-13	07/28/96	0.00	15:35	0.23	0.23	0.34	5.58	20.4	0.2	20		17.9734954	11.58		
MPG-13	07/29/96	1.00	08:35	-0.06	0.94	1.36	22.58	20.0	0.8	40					
MPG-13	07/29/96	1.00	19:47	0.41	1.41	2.03	33.78	20.0	1.1	52	NS 2 min purge				
MPG-13	07/30/96	2.00	08:50	-0.05	1.95	2.81	46.83	19.9	1.3	78	Purged water for 1 min then purged soil gas for 1 min.				
MPG-13	08/05/96	8.00	11:00	0.04	8.04	11.58	193.00	18.0	2.8	34	Purged water for 10 min then collected soil gas with Tedlar.				
VW2	07/26/96	0.00	08:40	0.00	0.00	0.00	0.00	20.8	0.05	26	0.10 5 min purge	20.3012265	0	0.000931	0.055835
VW2	07/26/96	0.00	09:25	0.03	0.03	0.05	0.75	20.7	0.1	160	0.13 5 min purge	14.9410803	5.76		
VW2	07/26/96	0.00	12:00	0.14	0.14	0.20	3.33	20.1	0.5	460	0.82 10 min purge				
VW2	07/26/96	0.00	16:05	0.31	0.31	0.45	7.42	19.7	1.0	750	2.1 10 min purge				
VW2	07/27/96	1.00	09:30	0.03	1.03	1.49	24.83	18.6	1.7	1,350	4.2 10 min purge				
VW2	07/27/96	1.00	15:25	0.28	1.28	1.85	30.75	18.1	2.0	1,550	4.6 10 min purge				
VW2	07/28/96	2.00	10:25	0.07	2.07	2.99	49.75	17.1	2.5	1,800	6.5 10 min purge				
VW2	07/28/96	2.00	16:05	0.31	2.31	3.33	55.42	16.9	2.8	1,900	6.3 10 min purge				
VW2	07/29/96	3.00	08:30	-0.01	2.99	4.31	71.83	16.7	2.8	2,100	7.0 10 min purge				
VW2	07/29/96	3.00	19:30	0.45	3.45	4.97	82.83	16.0	3.0	2,200	8.6 10 min purge				
VW2	07/30/96	4.00	08:40	0.00	4.00	5.76	96.00	15.0	3.1	2,400	10.0 10 min purge				
VW2	08/05/96	10.00	11:35	0.12	10.12	14.58	242.92	14.0	3.4	2,600	6.3 5 min purge				

# FORT CARSON-BUILDING 8200 - INITIAL Biodegradation Rate Calculations

Formula:  $K_b = K_o \times 1/100\% \times A \times D_o \times C$  Where:  
 $K_b$  = fuel biodegradation rate  
 $K_o$  =  $O_2$  utilization rate (%/min.)  
 $A$  = volume of air/kg soil  
 $D_o$  =  $O_2$  density = 1340 mg/L  
 $C$  = Carbon/ $O_2$  ratio for hexane mineralization = 1/3.5

Solving for 1 L of soil:

Monitoring Point:  
Oxygen util. rate  
Moisture content <sup>a/</sup>

VW2	%/min.
0.00093	
15.1	%

$K_o =$   
 $w =$

Soil Type <sup>b/</sup>

SILTY CLAY
------------

Porosity:

Unit weight (dry):

Void ratio:

Specific gravity:

$n =$	0.35
$\%d = G \cdot \%w \cdot (1-n) =$	1.72
$e = n/(1-n) =$	0.54
$G =$	2.65

Void volume:

Deg. of saturation:

Volume of water:

Volume of air:

$V_v = n \cdot 1 \text{ L} =$	0.35	liters
$S_r = Gw/e =$	0.74	
$V_w = S_r \cdot V_v =$	0.26	liters
$V_a = V_v - V_w =$	0.09	liters

Bulk density:

Air filled volume:

$\%d + (V_w \cdot \%w) =$	2	kg/L soil
$A = V_a/\text{Bulk Density}$	0.045	L air/kg soil

$$K_b = K_o \cdot 1/100\% \cdot A \cdot D_o \cdot C \cdot 525,600 \text{ min/yr}$$

$K_b =$	84	mg TPH/ kg soil/ year
---------	----	-----------------------------

<sup>a/</sup> Moisture:

<sup>b/</sup> Assume:

For each monitoring point, the moisture value represents an average of three samples.  
Soil properties are specified from Table 1.4. (Ref. Foundation  
Engineering, Peck, Hanson, and Thornburn, John Wiley Press, 1974)

MPD-10	MPD-18	MPG-13
0.00044	0.00077	0.00022
15.1	15.1	15.1

SILTY CLAY	SILTY CLAY	SILT, CLAY
------------	------------	------------

0.35	0.35	0.35
1.72	1.72	1.72
0.54	0.54	0.54
2.65	2.65	2.65

0.35	0.35	0.35
0.74	0.74	0.74
0.26	0.26	0.26
0.09	0.09	0.09

2	2	2
0.045	0.045	0.045

40	70	20
----	----	----

**APPENDIX B**  
**O&M CHECKLIST**

**DATA COLLECTION SHEET  
REGENERATIVE BLOWER SYSTEM  
BUILDING 8200  
FORT CARSON, COLORADO**

Date	Time	Blower Functioning Upon Arrival? (Y/N)	Inlet Vacuum (inches H <sub>2</sub> O)	Outlet Temperature (° F)	Outlet Pressure (inches H <sub>2</sub> O)	Comments	Checked by (Initials)